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The Indiana Enhanced I/M Program
1% On Road Testing 2011

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Glossary of Terms and Abbreviations

ADT	Average Daily Traffic
ASM	Acceleration Simulation Mode
Basic I/M	A set of vehicle I/M Program inspection requirements defined by the U.S. EPA that may be used in areas not required to implement an Enhanced I/M Program; the inspection procedure usually involves idle testing
BAR	California Bureau of Automotive Repair
BMV	Bureau of Motor Vehicles
CCM	Corner Cube Mirror
Clean Screening	The process of using RSD to identify vehicles with low emissions to exempt them from the required emission inspection at an inspection station
CO	Carbon monoxide
CO_2	Carbon dioxide
Cutpoint	An emissions level used to classify vehicles as having met an emissions inspection requirement
Decile	A group containing one-tenth of the entries in a value ordered set
Enhanced I/M	A set of more rigorous vehicle I/M Program inspection requirements defined by the U.S. EPA usually involving IM240 testing
Envirotest	Envirotest Systems Corporation
Evaporative Emitters	Vehicles releasing gaseous or liquid hydrocarbons from the fuel tank or fuel system
Excess Emissions	Vehicle emissions exceeding an I/M cutpoint
FTP	Federal Test Procedure
g/mi	Grams per mile, the units of measurement for FTP and IM240 tests
GVWR	Gross Vehicle Weight Rating
HC	Hydrocarbons
HDDV	Heavy-duty diesel vehicle
High-Emitter Identification	The on-road identification of vehicles with high emission levels
I/M	Inspection and Maintenance Program
IDEM	Indiana Department of Environmental Management

Idle Test	A tailpipe emission test conducted when the vehicle is idling and the transmission is not engaged
IM240 Test	A loaded-mode transient tailpipe emission test conducted when the vehicle is driven for up to 240 seconds on a dynamometer, following a specific speed trace simulating real world driving conditions
IM93 Test	A loaded-mode transient tailpipe emission test conducted when the vehicle is driven through a 93-second cycle on a dynamometer up to three times. The 93 seconds are the same as the first 93 seconds of the IM240 test.
IR	Infrared; electromagnetic radiation with a wavelength longer than that of visible light
KW/t	Kilowatts per metric ton, the units of measurement for vehicle specific power
LDDV	Light-duty diesel vehicle
LDGV	Light-duty gasoline-powered vehicle
LDGT	Light-duty gasoline-powered truck
NO	Nitric oxide also known as nitrogen monoxide
NO_2	Nitrogen dioxide
NO_X	Oxides of nitrogen, usually measured as nitric oxide (NO)
OBDII	On Board Diagnostic system to detect emissions related problems required on all 1996 and newer light–duty vehicles
OREMS	On-Road Emissions Monitoring System, a protocol and associated performance standards for remote sensing vehicle emissions testing developed by the California BAR since 1995
Positive Power	An operating mode where the engine is generating power to drive the wheels
Repairable Emissions	The emission reductions obtained by repairing a vehicle. The amount of repairable emissions is equal to or greater than the amount of excess emissions
RSD	Remote Sensing Device
SDM	Source Detector Module, an RSD component that measures emissions
Tag Edit	The transcription of vehicle license plates or tags from images to text
TSI	Two-Speed Idle test
U.S. EPA	United States Environmental Protection Agency
UV	Ultraviolet; electromagnetic radiation with a wavelength shorter than that of visible light, but longer than X-rays

UV Smoke	An RSD measurement of particulate matter using UV light
VIN	Vehicle Identification Number
VMT	Vehicle Miles Traveled
VSP	Vehicle Specific Power; estimated engine power divided by the mass of the vehicle
VTR	Vehicle Test Record

1 SUMMARY

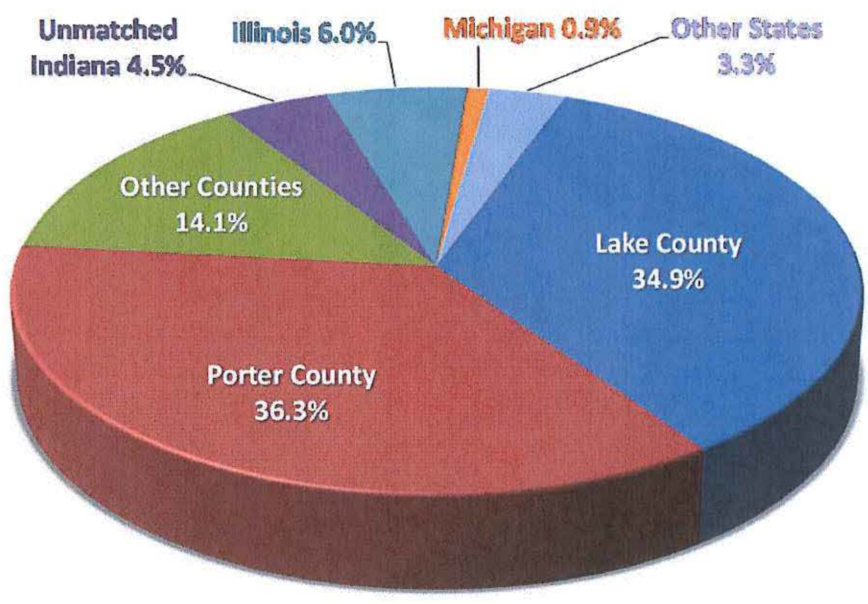
The Northern Indiana Inspection and Maintenance (I/M) Program contract between the Indiana Department of Environmental Management (IDEM) and Envirotest requires on-road testing of 1% of the subject vehicles every two years. This report covers on-road testing performed in 2011 in the Northern Indiana I/M area comprising Lake and Porter counties. A remote sensing device (RSD) was used at roadside locations to measure emissions of passing vehicles and capture images of the vehicle plates. The vehicle plates were matched to registration records to obtain information about the type, age and weight class of the vehicle measured.

Envirotest collected 24,262 valid on-road vehicle emissions measurements from eight roadside locations from June through November 2011. License plates were decoded for 20,798 of the vehicles measured and 14,796 of these were matched to vehicle registrations in Lake and Porter County. A further 2,941 were matched to vehicles in other Indiana counties.

Survey Results

The chart below shows the registered jurisdiction of the vehicles measured in the nonattainment region. Of the 20,798 vehicles measured with readable plates, 71.2% were registered in the two counties, 14.1% were registered in other counties, 4.5% were unmatched and 14.7% were from other states.

Figure 1-1: Registration Jurisdictions of Vehicles Measured in Lake and Porter Counties



On-road Vehicle Emissions

The average emissions of vehicles registered in the jurisdictions are shown in Table 1-1. Average emission rates of all vehicles measured on-road in the two counties, regardless of where they were registered, were 0.09 % carbon monoxide (CO) 12 ppm hydrocarbon (HC) hexane and 122 ppm oxides of nitrogen (NO_x).

Vehicles registered in Indiana counties outside the I/M area had average HC, CO, and NO_x emissions of 45%, 47% and 52% higher respectively than the average emissions of vehicles registered in Lake and Porter counties. The difference resulted from a combination of an older age profile and higher emissions for vehicles in the same age range – especially for light trucks.

Compared to Lake and Porter registered vehicles, vehicles from Illinois and Michigan also had higher emissions of HC, CO and NO_X. Vehicles from other more distant states had emissions similar or lower than Lake and Porter registered vehicles.

Table 1-1 Fleet Emissions by Registered I/M Area

Jurisdiction	N	CO	HC	NOx	Smoke	VSP
Lake County	7,254	0.09	15	116	0.013	14.4
Porter County	7,542	0.08	8	110	0.010	14.7
Other Indiana Counties	2,941	0.12	17	171	0.017	14.5
Unmatched Indiana	935	0.08	8	103	0.009	14.4
Illinois	1,253	0.12	20	124	0.014	14.0
Michigan	194	0.11	26	179	0.010	14.9
Other States	679	0.06	9	105	0.006	14.0
Total	20,798	0.09	12	122	0.012	14.5

Figure 1-2 shows average emissions by age for Lake and Porter passenger vehicles and light-duty trucks. Vertical lines with bars indicate 95% confidence intervals of the average values. RSD UV Smoke is a measurement of particulate emissions (PM). For diesel smoke, an RSD UV smoke value of one corresponds to one gram of particulate per 100 grams of combusted fuel. For gasoline vehicles the relationship between the RSD UV smoke value and particulate mass is less well defined and depends on the type of smoke, e.g. black carbon smoke, blue oil smoke or white coolant smoke, and is the subject of ongoing research.

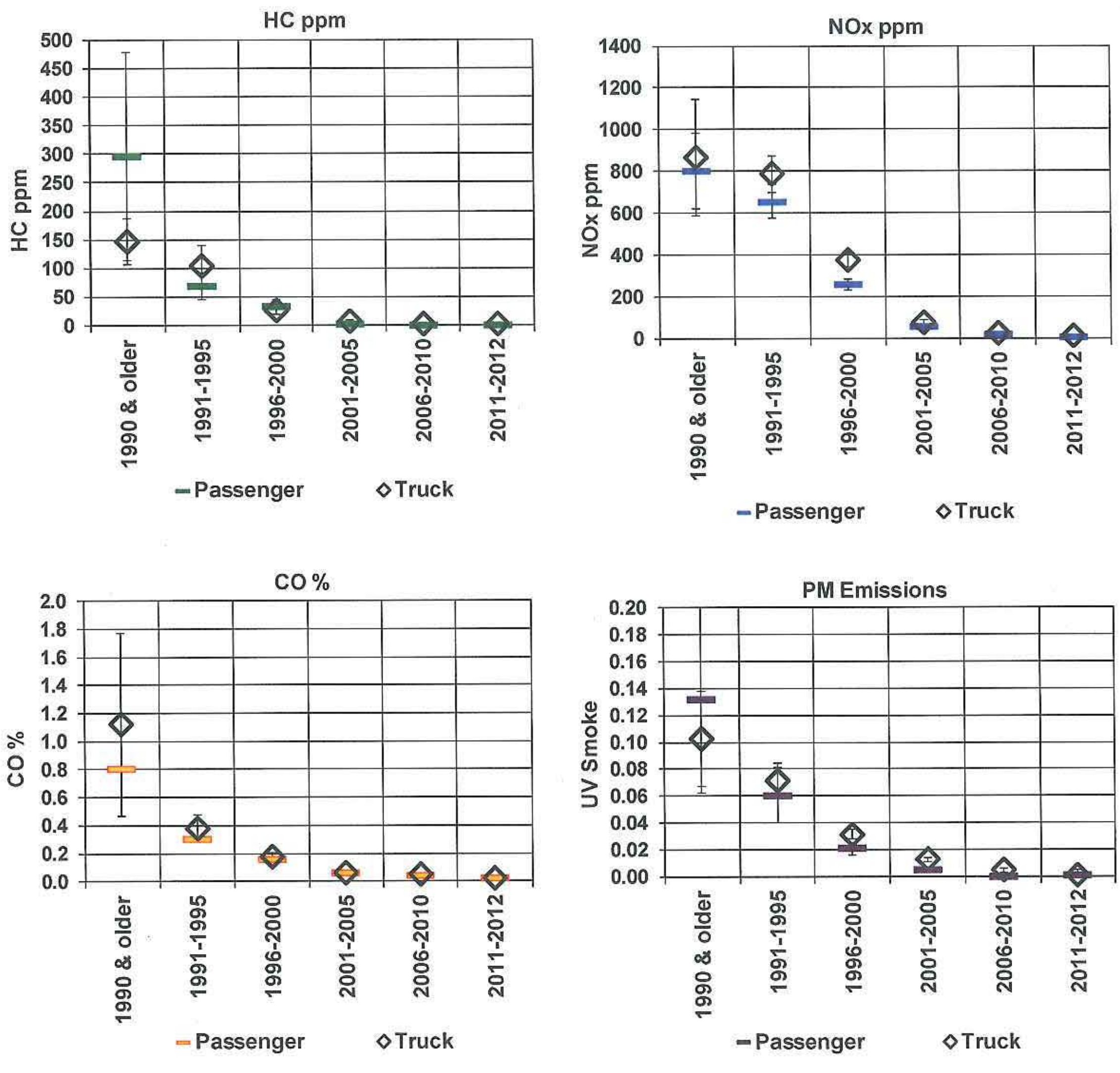
Emissions of 1996 and newer models were much lower than those of older models. The vast majority of 2001 and newer models had very low emissions. With the exception of the small sample of 1990 and older models, trucks consistently had higher average emissions than passenger vehicles for all pollutants. Light-duty trucks also have lower fuel economy and greater exhaust volume resulting in a larger mass of emissions.

Compliance with the I/M Program

Inspection records from January 2009 through December 2011 were examined to determine the last inspection for the vehicles measured on-road. I/M inspections were confirmed for 95.9% of the Lake and Porter 1981-2005 passenger models, and 96.8% of trucks with a gross vehicle weight rating (GVWR) of up to 6,000lbs.

Confirmed inspection rates were higher for odd model year vehicles than for even model year vehicles.

Figure 1-2: Emissions by Vehicle Type and Model Year



High-Emitters

Gasoline powered vehicles had a highly skewed emissions distribution with a small percentage of high-emitters contributing a substantial portion of total light-duty vehicle emissions.

Envirotest identified high emitters using criteria used in similar on-road surveys conducted in Maryland. The criteria required at least two measurements to confirm a vehicle as being a high emitter. Thirty-two vehicles, 1.7% of vehicles with two or more measurements, exceeded the cutpoints on both of their last two measurements for the same pollutant. The thirty-two vehicles had average emissions of 329 ppm HC, 0.6% CO, and 1,503 ppm NO_X.

Forty percent of high emitters were 1999 and older models and 19% were registered outside the two counties.

Recommendations

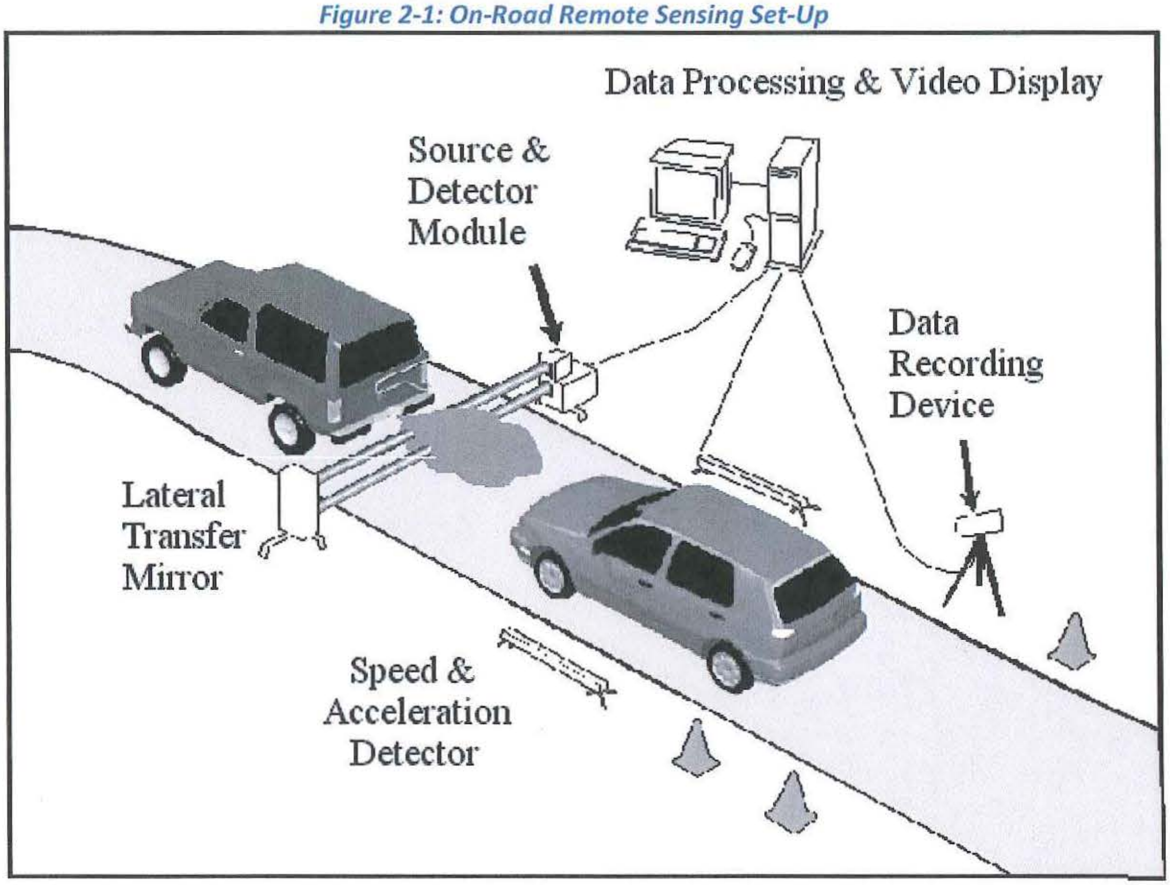
- A comprehensive on-road emissions measurement program could be a valuable supplement to the current I/M Program by:
    - Exempting clean vehicles from having to visit an inspection station;
    - Identifying on-road evaporative emitters, some of which will not be identified by OBD-II;
    - Identifying high-emitters not captured by the I/M Program, or failing between tests;
    - Identifying smoking vehicles;
    - Monitoring on-road vehicles for compliance;
    - Providing feedback on the effectiveness of the Program and repairs; and,
    - Examining the impact of OBD-II readiness exemptions and other I/M Program design decisions and options, e.g. the inclusion or exclusion of additional models.
- Consider dual testing (IM93 and OBD-II) for 1996 to 1999 model year vehicles given the numbers of high-emitters for these models. California currently dual tests OBD-II models and will continue to dual test 1996-1999 models after legislation[1] to allow OBD-II only testing of 2000 and newer models becomes effective in 2013. The legislation also allows for dual-testing of 2000 and newer models with emission problems that may not be adequately detected by the vehicle's OBD-II system.
- Consider raising the GVWR limit on vehicles tested from 9,000lbs to 10,000lbs or 14,000lbs. These heavier trucks have higher mass emissions and delivery trucks and shuttles have high vehicle miles traveled (VMT).
- Consider emissions testing for light- and medium-duty diesel powered vehicles. Light- and medium-duty diesel vehicles, although fewer in number, have particulate and NO_X emissions that are many times higher than gasoline vehicle emissions. Smoking diesel vehicles cause the public to question whether I/M programs are targeting the right vehicles.

2 EQUIPMENT AND SITES

2.1 Equipment Description

The remote sensing device (RSD) survey used the Envirotest RSD4600 testing system. The RSD4600 detects vehicle emissions when a vehicle drives through an invisible light beam the system projects across a roadway. Figure 2-1 illustrates the remote sensing equipment set-up. The process of measuring emissions remotely begins when the RSD4600 Source & Detector Module (SDM) sends an infrared (IR) and ultraviolet (UV) light beam across a single lane of road to a Corner Cube Mirror (CCM). The mirror reflects the beam back across the street (creating a dual beam path) into a series of detectors in the SDM.

Figure 2-1: On-Road Remote Sensing Set-Up



Fuel specific concentrations of HC, CO, CO_2, NO, and smoke are measured in vehicle exhaust plumes based on their absorption of IR/UV light in the dual beam path. During this process, the data-recording device captures an image of the rear of the vehicle, while the Speed & Acceleration Detector measures the speed of each vehicle.

The RSD units are housed in fully outfitted cargo-style vans. These vans are equipped with heating/cooling, a generator, and adequate storage for all components. The vans carry a full complement of road safety equipment and tools for making small repairs. The vans are equipped with additional lighting for testing during pre-dawn and post-dusk hours. The RSD4600 includes the following features:

1) A long beam range for safer, more versatile deployment;
2) Simple and easy setup with laser alignment aids;
3) Continuous automatic background compensation minimizes the need for field calibration. (Only one or two calibrations are generally required during a full day of data collection);
4) Fourth generation real-time measurement validation;
5) Signal sensitivity and accuracy that significantly exceed 2002 California BAR certification standards;
6) Limited degrees of freedom in alignment resulting in improved optical stability and low noise for increased productivity, yielding more valid records;
7) A Windows operating system for ease of operation and multi-tasking;
8) A fuel specific smoke measurement using a UV wavelength that senses the fine particles invisible to traditional visible light opacity meters; and,
9) Rugged assemblies requiring low maintenance.

2.2 Equipment QA/QC Audits

2.2.1 Factory Testing and Certification

When an RSD system is built at the Tucson Technology Center, it undergoes several steps to ensure accuracy. First, the source detector module is bench calibrated. It is then audited using several blends of gas. When the system is fully calibrated and assembled, it is tested again in the parking lot using an audit truck. The unit tests are based on the BAR OREMS specification.

An audit truck is a modified vehicle that uses a long exhaust stack to redirect the vehicle engine exhaust upwards and away from the roadway. Audit gases of known concentrations are dispensed through a simulated tailpipe routed to the rear of the audit truck. When the truck is driven past a roadside remote sensing SDM/CCM set of modules, the system measures the pollutant concentrations in the dispensed test gas instead of the vehicle engine exhaust.

The remote sensing unit is setup in a parking lot to avoid interference from other traffic. The auditor drives the audit truck through the remote sensing system 40 times for each gas blend during acceptance testing. Envirotest detector accuracy, including speed and acceleration, will meet the detector accuracy tolerances shown below for at least 97.5% (39/40) runs for each gas. Six different audit gas blends are used to verify the unit accuracy over a range of pollutant concentrations.

2.2.2 Detector Accuracy

The carbon monoxide (CO%) reading will be within ± 10% of the Certified Gas Sample, or an absolute value of ± 0.25% CO (whichever is greater), for a gas range less than or equal to 3.00% CO. Negative values shall be included and will not be rounded to zero. The CO% reading will be within ± 15% of the Certified Gas Sample for a gas range greater than 3.00% CO.

The hydrocarbon reading (recorded in ppm propane) will be within ± 15% of the Certified Gas Sample, or an absolute value of ± 250 ppm HC, (whichever is greater). Negative values will be included and will not be rounded to zero.

The nitric oxide (NO) reading (ppm) will be within ± 15% of the Certified Gas Sample, or an absolute value of ± 250 ppm NO, (whichever is greater). Negative values shall be included and will not be rounded to zero.

2.2.3 Speed and Acceleration Accuracy

The vehicle speed measurement will be accurately recorded within ± 1.0 mile per hour.

The vehicle acceleration measurement will be accurately recorded within ± 0.5 mile per hour / second.

2.2.4 Daily Set-Up and Calibration

Every scheduled work day, the operator drives to an existing or new test site. The operator's first duty is to provide a safe work area for themselves and passing motorists. The next step is to set up the source detector module and allow the electronic components within to warm up for a minimum of 30 minutes. Following the set up and alignment of the other components, the SDM is aligned and ready for calibration.

An automated calibration utilizing a mechanized gas cell within the SDM is a method of testing the equipment without the need to drive an audit truck past the unit. During a gap in the passing traffic, a test gas within a sealed cell, with a known blend of HC, CO, CO_2, and NO, is maneuvered into the optical path of the remote sensing beam. If necessary, the instrument set-up is adjusted so that the pollutant values measured by the unit, match the known concentrations of pollutants in the test gas blend.

Calibration for the RSD4600 occurs once at the beginning of the day and at mid-day if conditions warrant.

2.2.5 Equipment Audits

After each daily calibration, the operator is required to perform an audit to verify an optimal calibration. A puff audit is a method of testing the equipment without the need to drive an audit truck past the unit. During a gap in the passing traffic, a test gas with a known blend of HC, CO, CO_2 and NO, is puffed into the optical path of the remote sensing beam. If the audit passes a predetermined pass/fail tolerance, the operator is allowed to begin testing vehicles. If not, the operator is required to realign and recalibrate the system until it passes the audit process.

Audits for the RSD4600 occur every hour (2 hour maximum before system lockout occurs), twice when a calibration is performed (once before to earmark data and once after to begin testing) and once at the end of the test collection period to earmark the data.

2.3 Overview of 0.5% Sample

2.3.1 Sample Design Criteria

The objective is to obtain the 0.5% sample from sites that will be generally representative of vehicles operating in the I/M program areas.

As shown in Figure 2-2: Site Locations, eight sites were used to collect RSD data. The intent was to collect tests on a random sample that is representative of all the on-road vehicle traffic.

Measurements are distributed geographically with no one area receiving an undue amount of testing.

2.3.2 Description of Sample Site Characteristics

Site selection is critical to obtaining RSD measurements that are representative of vehicle operation. Recommended site attributes include:

- Absence of cold start vehicle operating conditions;
- Sites where vehicles will generally be accelerating or driving at a steady speed uphill to avoid the highly variable tailpipe emissions that can occur under deceleration;
- Absence of enrichment due to high load conditions;
- Single lane operation;
- High volume traffic;
- Unobtrusive citing of the remote sensing equipment;
- Stability in the traffic mix from one year to the next; and,
- Adequate median space for safe operation of the RSD equipment

2.4 Sites selected for studies

Table 2-1 lists the site locations selected for the 0.5% sample. All the sites selected are on-ramps or exit loops that provide the required physical characteristics of an appropriate RSD site. Sites were pre-qualified for:

- Single lane operation with space for the RSD equipment to be deployed without disrupting traffic flow;
- Geographically dispersed throughout the I/M area;
- A satisfactory percentage of valid readings; and,
- An adequate traffic volume.

2.4.1 Sites Used

Table 2-1 shows the survey sites used and the number of valid measurements obtained.

Figure 2-2 displays the distribution of the sites.

Detailed descriptions of the sites with pictures and layouts are in Appendix A

Table 2-1: Sites Used

Site Code	Location	City	County	Degrees of Grade	Valid RSD in Desired VSP Range
IN03	61st Ave West to I-65 North	Merrilville	Lake	0.08	645
IN05	IN 2 to IN 49 South	Valparaiso	Porter	0.76	4,550
IN07	IN 2 to IN 49 North	Valparaiso	Porter	1.20	2,967
IN16	US 30 to IN 49 North	Valparaiso	Porter	0.20	4,477
IN30	US 231 to I-65 North	Crown Point	Lake	1.30	6,737
IN32	IN 249 South to I-94 West	Portage	Porter	-0.20	40
IN35	109th St to I-65 North	Crown Point	Lake	0.36	3,301
IN36	Burr St to I-80 / I-94 East	Gary	Lake	0.60	1,545
Total					24,262

Figure 2-2: Site Locations

2.5 Data Screening

The RSD system applies checks to determine the validity of emissions measurements. These include determining if a sufficient exhaust plume was measured. The general criteria for an RSD system 'valid' measurement include:

- The system was active and calibrated;
- A valid exhaust gas measurement was recorded;
- A valid speed and acceleration was recorded; and,
- A readable plate was recorded and transcribed.

Particular applications can require further screening. Envirotest applied the following additional screening checks to the RSD measurements to ensure the data used were representative of the vehicle emissions:

- Screening for Vehicle Specific Power (VSP) range; and,
- Screening of hourly observations to check for cold starts.

The exhaust plume validations and the additional screening procedures are described in the following paragraphs.

2.5.1 Valid Exhaust Plumes

The RSD4600 unit takes many measurements of each exhaust plume in the one half second after each vehicle passes the equipment.

The basic gas record validity criteria applied are:

- A gas record is valid if there are at least 5 plume measurements where the sum of the amount of CO_2 and CO gas exceed 10%-cm[i]; or
- A gas record is valid if there are at least 5 plume measurements where the sum of the amount of CO_2 and CO gas exceed 5%-cm and the background gas values are very stable (not changing faster than a specified rate) at the time the front of the vehicle breaks the measurement beam.

2.5.2 Vehicle Specific Power (VSP)

VSP provides an estimate of the relative power output of the vehicle based upon speed, acceleration and slope at the site and for light-duty vehicles is defined by the following equation:

VSP = 4.364*sin(Grade in Deg/57.3)*Speed + 0.22*Speed*Accel + 0.0657*Speed + 0.000027*Speed*Speed*Speed

[i] The unit of measurement 10%-cm is a measurement of the amount of a gas in the optical path. In this case, if all the molecules of the gas in the path were collected together into just one centimeter of the path then the concentration of the gas in the one-centimeter would be 10%.

Engine load is a function of the vehicle speed and acceleration, the slope of the site, vehicle mass, aerodynamic drag, rolling resistance, and transmission losses. The effects of these forces can be aggregated into a single parameter called VSP, which was the topic of a presentation at the Ninth Coordinating Research Council (CRC) On-road Vehicle Emissions Workshop[2]. The CRC E-23 Project[34] further developed the concept of vehicle specific power. In 2002, EPA adopted the use of VSP as a parameter for predicting vehicle emissions in the recently adopted Motor Vehicle Emissions Simulator (MOVES) emissions inventory model that replaces Mobile6[5].

Studies have found vehicle emissions to be more stable and more representative of the average in-use emissions of a vehicle when the engine is under a light to moderate load such as occurs when cruising above 30 mph, during non-aggressive acceleration, or driving up inclines. In day-to-day use, a majority of fuel is consumed in light to moderate engine load. Therefore Envirotest requires that vehicle emission observations be made when VSP is positive and sites are selected to measure vehicles when they are typically operating with moderate engine load. For CO high-emitter identification, upper limits are placed on VSP depending on the model year.

2.5.3 Screening of Hourly Observations

Envirotest is concerned about vehicles operating in cold start mode or under conditions when exhaust plumes condense to steam. Vehicles measured under these conditions could appear to have high HC emissions without any emission system problems. To investigate this possibility, Envirotest tabulated for each site and hour the percentage of vehicles up to 5 years old that exceeded 150 ppm HC (Table 2.3). The percent of vehicles up to 5 years old that exceed 150 ppm HC tend to be higher during periods of near freezing temperatures. All hours with ten or more measurements had less than 5% of new models with emissions greater than 150 ppm HC. Table 2-4 shows that temperatures were never close to freezing. Temperatures also never exceeded 100°F, which can lead to high evaporative emissions.

Table 2-3: Percentage of New Model Measurements Exceeding 150 ppm HC

Day	Unit	Site	06:00 & earlier	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00
1-Jun-11	__06064605	IN30			1%	0%	0%	0%	0%	0%	0%	0%	0%
8-Jun-11	__06064605	IN30		0%	2%	0%	0%	0%	0%	0%	0%	0%	0%
17-Jun-11	__06064605	IN30	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%
30-Jun-11	__06064605	IN35	0%	0%	0%	0%	0%	0%	0%	0%	3%	0%	0%
6-Jul-11	__06064605	IN35	0%	0%	0%		0%	0%	0%	0%	0%	5%	0%
8-Jul-11	__06064605	IN03		0%				0%	0%	0%	0%		
22-Jul-11	__06064605	IN05		0%	0%	0%							
27-Jul-11	__06064605	IN05		0%	0%	0%	0%	0%					
10-Aug-11	__06064605	IN05				0%	0%	0%	0%	0%	0%		
11-Aug-11	__06064605	IN05				0%	0%	0%	0%	0%			
17-Aug-11	__06064605	IN16		0%	0%	0%	0%	0%	0%	0%	0%	0%	
18-Aug-11	__06064605	IN16		0%	0%	0%	0%	0%	0%	0%	0%	0%	
19-Aug-11	__06064605	IN16		0%	0%	0%	0%	0%	0%	0%	0%	0%	
31-Aug-11	__06064605	IN36						0%	0%	0%	0%		
1-Sep-11	__06064605	IN36							0%	0%	0%		
6-Sep-11	__06064605	IN36						0%	0%	0%	0%	0%	
5-Oct-11	__06064605	IN05						0%					
7-Oct-11	__06064605	IN05					0%	0%	0%	0%	0%		
12-Oct-11	__06064605	IN05					0%	0%	0%	1%	0%		
14-Oct-11	__06064605	IN07						0%	0%	0%	0%		
21-Oct-11	__06064605	IN07					3%	2%	0%	0%	0%	0%	
2-Nov-11	__06064605	IN07					0%	0%	0%	0%	0%		
4-Nov-11	__06064605	IN07				0%	2%	2%					
16-Nov-11	__06064605	IN32											

Table 2-4: Average Hourly Temperature Fahrenheit

Day	Unit	Site	06:00 & earlier	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00
01-Jun-11	06064605	IN30			81	85	86	86	86	86	86	85	84
08-Jun-11	06064605	IN30		86	92	94	97	99	100	100	99	97	95
17-Jun-11	06064605	IN30	73	79	87	89	89	92	93	93	93	94	92
30-Jun-11	06064605	IN35	66	70	75	80	83	88	93	93	94	95	94
06-Jul-11	06064605	IN35	75	79	81		88	92	96	93	96	96	94
08-Jul-11	06064605	IN03	68	71	75	78	81	82	86	87	90	91	
22-Jul-11	06064605	IN05	81	82	84	88	89						
27-Jul-11	06064605	IN05	73	74	79	80	81	83	86				
10-Aug-11	06064605	IN05				72	73	75	78	81	83		
11-Aug-11	06064605	IN05				93	89	87	91	89			
17-Aug-11	06064605	IN16		67	72	76	81	84	86	89	93	95	
18-Aug-11	06064605	IN16	71	72	76	80	84	86	89	90	93	91	
19-Aug-11	06064605	IN16	67	69	73	79	84	86	88	93	94	98	
31-Aug-11	06064605	IN36					79	82	85	87	88		
01-Sep-11	06064605	IN36						91	92	96	97	98	
06-Sep-11	06064605	IN36					64	66	67	68	69	69	
05-Oct-11	06064605	IN05						88	88				
07-Oct-11	06064605	IN05					82	86	87	87	86	86	
12-Oct-11	06064605	IN05					78	79	80	79	77		
14-Oct-11	06064605	IN07						60	62	64	64		
21-Oct-11	06064605	IN07					50	54	55	59	65	70	
02-Nov-11	06064605	IN07					60	63	68	70	68	67	
04-Nov-11	06064605	IN07				44	49	54					
16-Nov-11	06064605	IN32				56							

2.5.4 Screening of Day-to-Day Variations in Emission Values

Each day's emission measurements of 2006 and newer model year vehicles were ordered by value and divided into ten groups or deciles each containing an equal number of the ordered measurements. Day-to-day decile emission values were compared for 2006 and newer vehicles. Only a small percentage of these newer vehicles are expected to have high emissions and, therefore, the decile emission values for the lower nine deciles should not vary significantly from day-to-day, from site-to-site, or between RSD units. In Figure 2-3, the lower nine daily HC decile values of measurements are plotted side-by-side. The right hand legend indicates the color of each decile number. This comparison revealed median values for 2006 and newer model year vehicles that ranged day-to-day from –21 ppm to -6 ppm. Although these variations are well within the HC specification of the RSD units they are significant compared to average fleet emissions for newer vehicles.

The most likely explanation is that this represents the limits of accuracy in the daily instrument set-up although it is unusual that the median would be negative on all days. For HC, an adjusted set of values was created by direct addition or subtraction of a daily offset that would set the daily median values to zero. We believe this is appropriate since the median I/M test result for new models is normally zero or very close to zero. The results of the correction are shown in Figure 2-4 and analyses shown later in this report used the adjusted HC values.

Day-to-day decile CO, NO, and UV smoke values for 2006 and newer model year vehicles are shown in Figures 2-5 to 2-7. Median values for CO, NO, and smoke were -0.00% to +0.02%, -7 to +11 ppm and -.02 to +0.01 respectively. These negative and positive values are very small and adjustments were not applied to these pollutants.

Figure 2-3: Daily HC Deciles

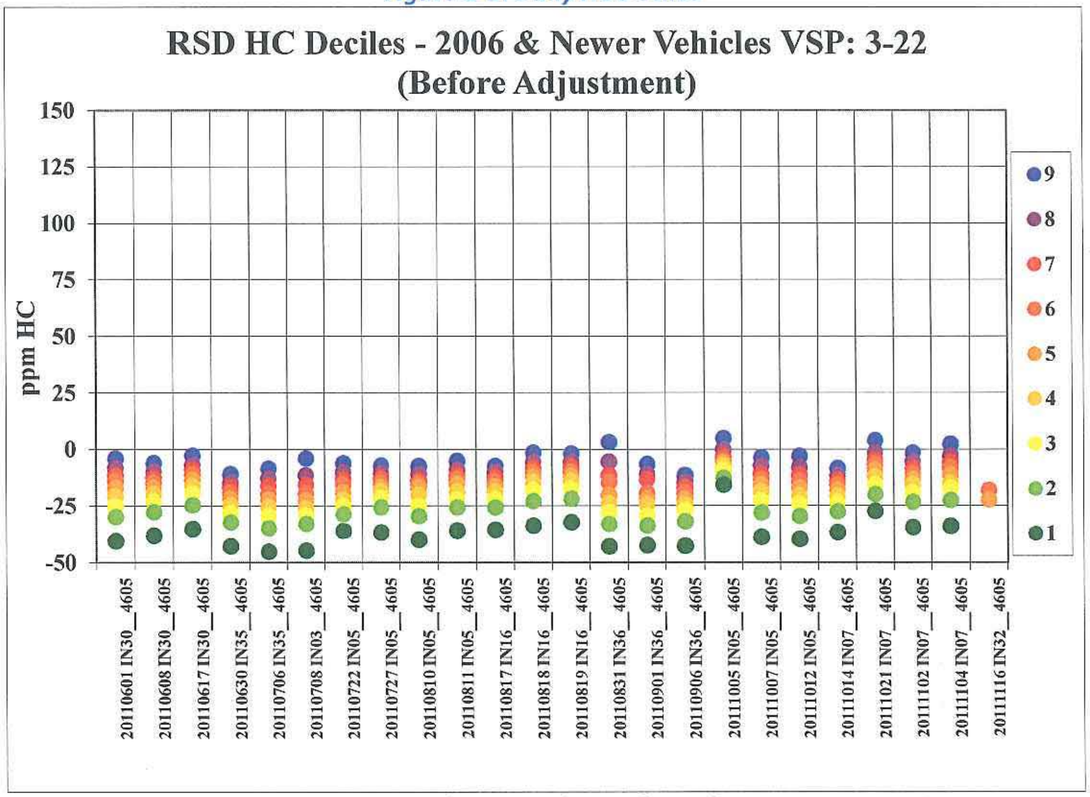


Figure 2-4: Daily HC Deciles – After Adjustment

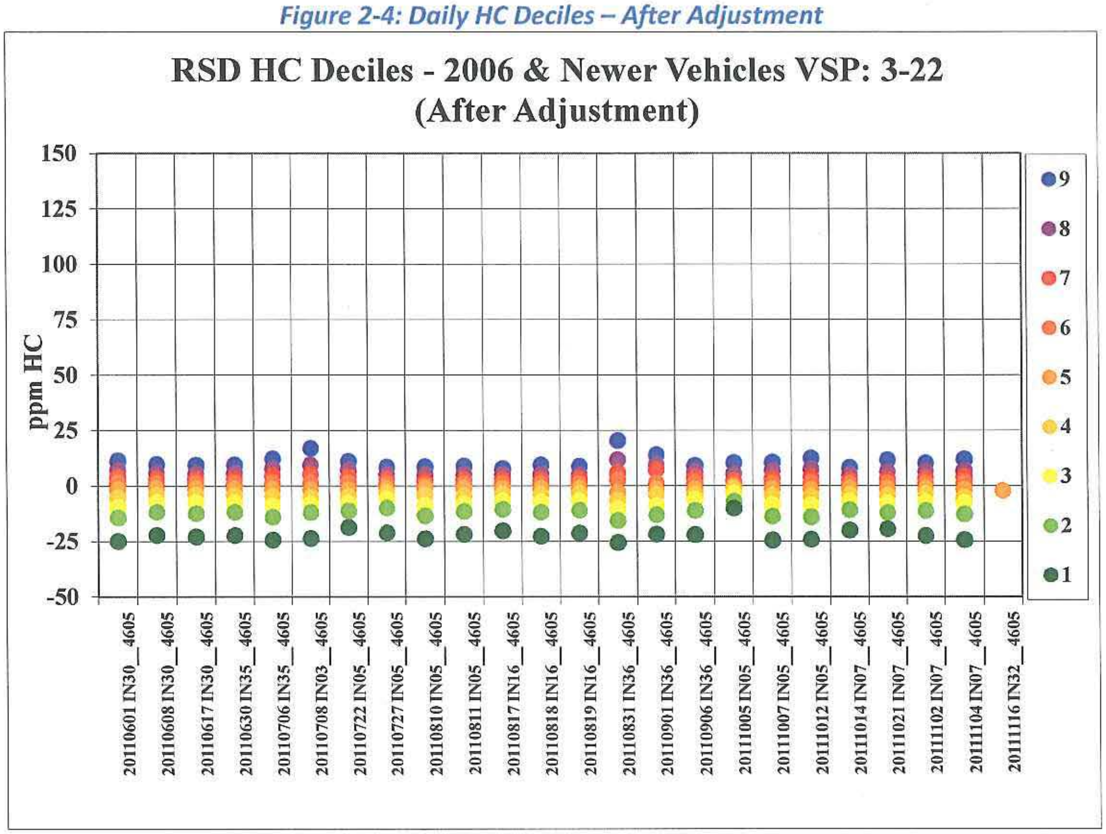


Figure 2-5: Daily CO Deciles

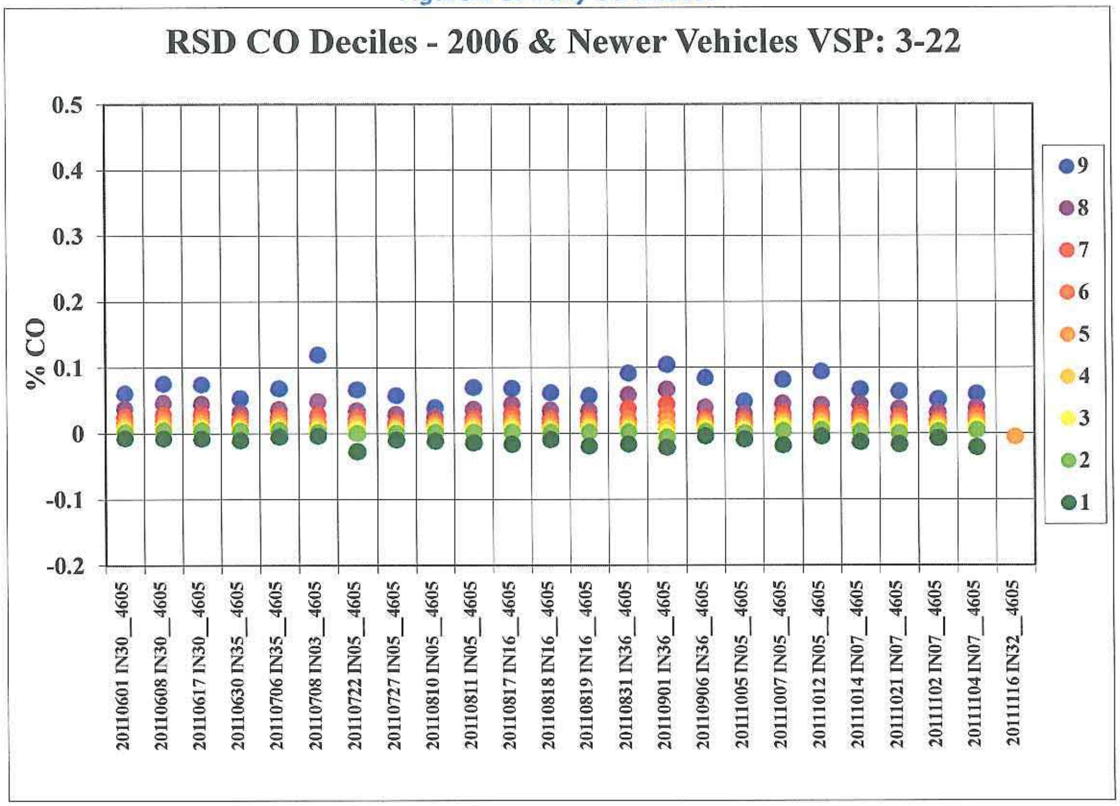


Figure 2-6: Daily NO Deciles

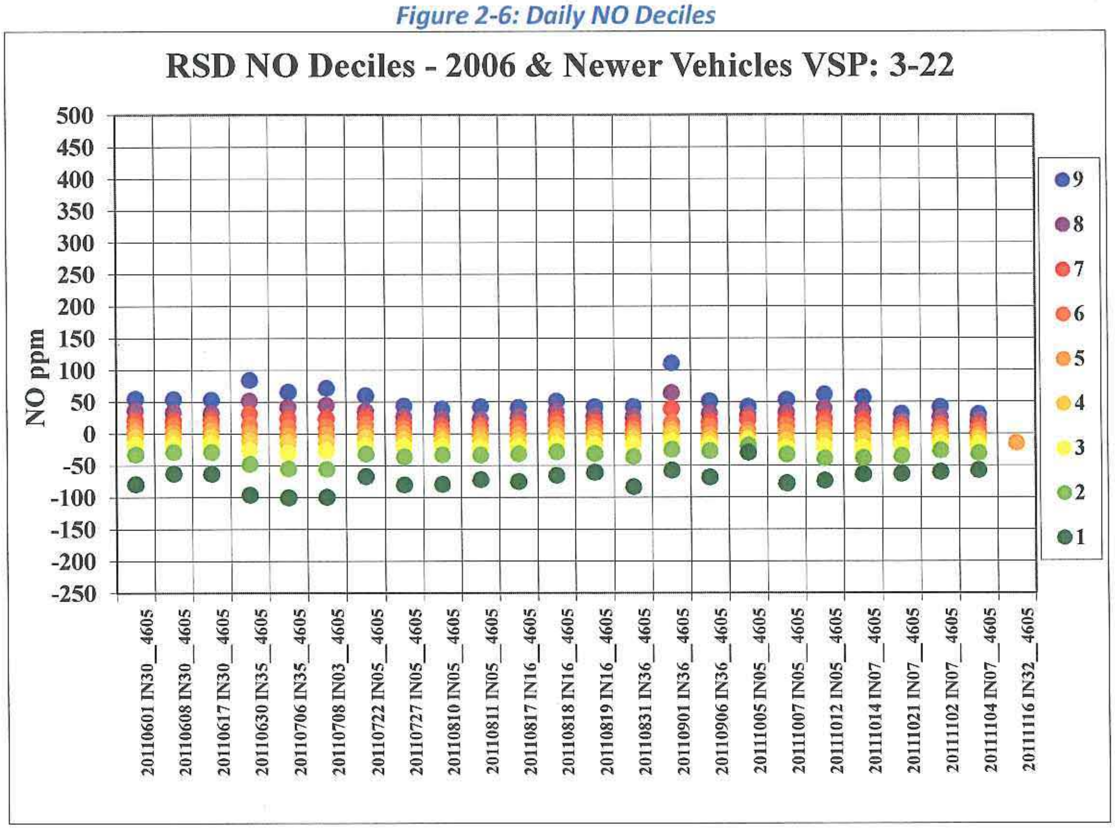
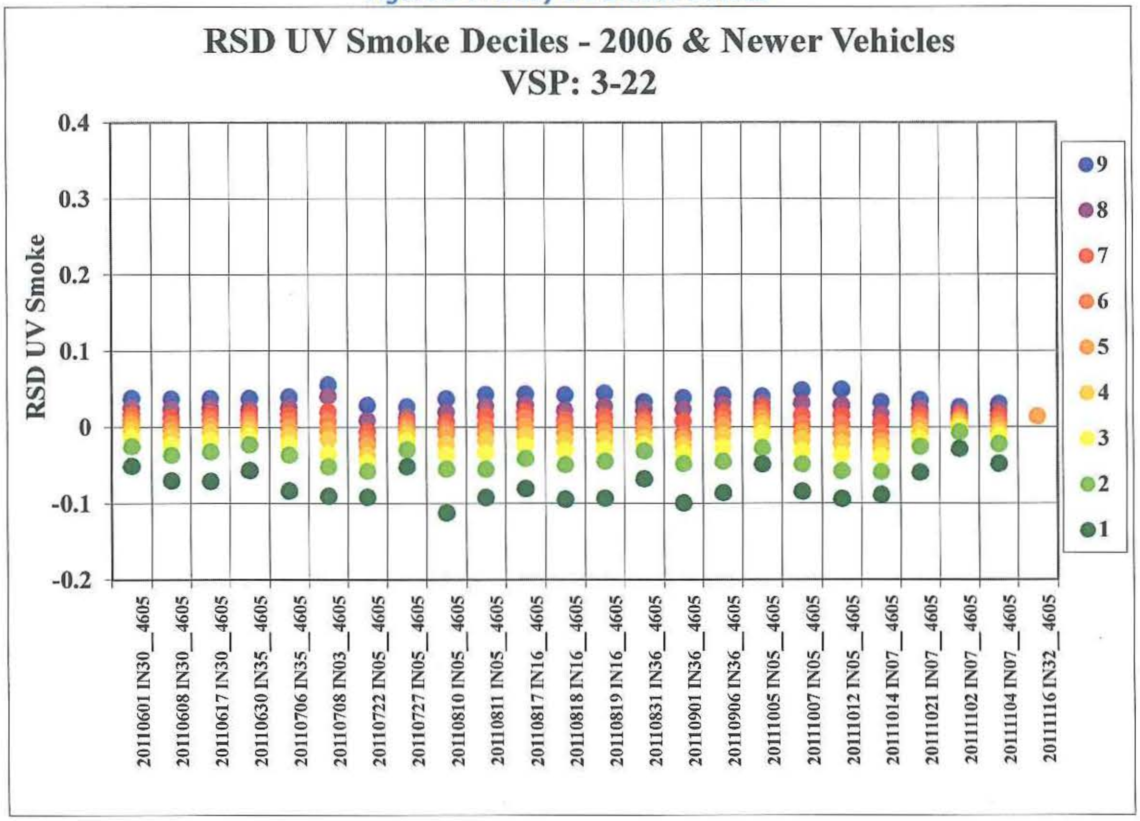


Figure 2-7: Daily UV Smoke Deciles



2.6 Sources of Data and Description of Elements

Data used in the analyses in this report come from two primary sources, the RSD on-road measurements and the Bureau of Motor Vehicles (BMV) registrations database.

In the following description of data elements, key fields that are used to access other tables are shown in **bold**.

2.6.1 RSD Measurements

For each vehicle the following information is collected:

- **Vehicle Plate or tag;**
- Date and Time;
- **Site Reference;**
- HC, CO, CO_2, NO, and UV Smoke emissions; and,
- Speed and acceleration.

2.6.2 RSD Sites

For each site the following information is collected:

- **Site Reference;**

- Description of location; and,
- Slope of site in degrees.

2.6.3 Vehicle Registration Data

Data from the RSD is matched to the vehicle registrations data provided by BMV. Using the vehicle plate identified by RSD, the registration file is accessed to determine the vehicle identification number (VIN) and additional information about the vehicle such as model year and county in which it is registered. In order to obtain an accurate match, the plate number, a two-letter plate type and the registration year are required. BMV uses a series of plate types and in the past the same plate number was sometimes be issued to more than one plate type. This practice is being phased out and only a handful of instances were observed among approximately 450,000 2011 BMV records. For this survey, plates were initially matched to BMV 2011 and 2010 records for Lake and Porter counties and a small balance of unmatched vehicles were matched to plates in I/M test records. A balance of 5,500 unmatched plates were then sent to BMV for matching to the statewide registration database.

Another limitation is that vehicle plates do not always remain with the same vehicle. Upon purchase of a new or used vehicle, an owner may transfer the same plate from the old vehicle to the new vehicle. In this situation, data processing delays can result in incorrect identification of some vehicles measured by RSD unless BMV transaction dates are included in the data, which was not the case for this survey.

2.6.4 NO vs. NO_X

The vast majority of nitric oxides emitted from gasoline vehicle tailpipes are in the form of NO. The NO is later oxidized to NO_2 and other oxides of nitrogen, which are collectively referred to as NO_X.

To convert from NO to NO_X, a factor of 1.03 is applied. Subsequent sections in the report show NO_X values. In Section 5, where individual vehicles are compared to standards for determination of high emitters, the NO values are converted to NO_X and also adjusted for humidity as described below.

2.6.5 NO_X and Humidity

Higher humidity reduces vehicle NO_X emissions. When vehicles are inspected in the I/M program, humidity correction factors are applied to adjust NO_X measurements to values that would have been achieved when the water vapor content is 75 grains per lb. For temperatures above 75 degrees Fahrenheit (ºF):

Correction factor = e^(.004977*(H-75) - .004447*(T-75))

For temperatures below 75 ºF:

Correction factor = 1/(1.0 - .0047*(H - 75.0))

Where:

H = absolute humidity in grains of water/lb dry air
T = Temperature (ºF)

Both of the correction factors are capped at a value of 2.19.

Correction factors were calculated using weather information recorded by the weather station attached to the RSD van. Water vapor grains per lb were determined using the temperature, relative humidity and barometric pressure:

Saturated Vapor Pressure = $(-4.14438 \times 10^{-3} + 5.76645 \times 10^{-3} \times [\text{Temp ºF}] - 6.32788 \times 10^{-5} \times [\text{Temp ºF}]^2 + 2.12294 \times 10^{-6} \times [\text{Temp ºF}]^3 - 7.85415 \times 10^{-9} \times [\text{Temp ºF}]^4 + 6.55263 * 10^{-11} \times [\text{Temp ºF}]^5)*25.4$

Grains per lb = (43.478 x [Relative Humidity] x [Saturated Vapor Pressure]) / (([Barometric pressure Hg mm])-([Saturated Vapor Pressure]*[Relative Humidity]/100))

The vehicle NO_X emissions reported in Section 5 have been adjusted for humidity.

3 VEHICLE EMISSION DATA COLLECTED

3.1 RSD Sample Quantity

3.1.1 Data Collection Summary

The number of light-duty vehicles registered in the Northern I/M area (Lake and Porter counties) is approximately 450,000. The requirement of a 1% sample of subject vehicles therefore requires 4,500 measurements.

In total, 24,265 RSD measurements were made from June 1st through November 16th 2011. These statistics include duplicate instances of the same vehicle where the vehicle has been measured by RSD more than once. Data were collected from eight sites.

Table 3-1: Remote Sensing Measurements Summary

Item	Quantity	%
RSD valid HC, CO, NOx, Speed & Acceleration		
and in desired operating mode (VSP)	24,265	
Additional screening:		
NOx values less than -250 ppm	3	0.0%
Valid and in desired VSP range after screening	24,262	
Valid with readable plate or state	20,798	85.7%
Of which:		
Indiana plate read	18,672	89.8%
Out of State License Plate	2,126	10.2%
Indiana plates read:		
Matched to BMV Lake/Porter Registrations	14,796	79.2%
Matched to BMV Other Counties	2,941	15.8%
Unmatched	935	5.0%

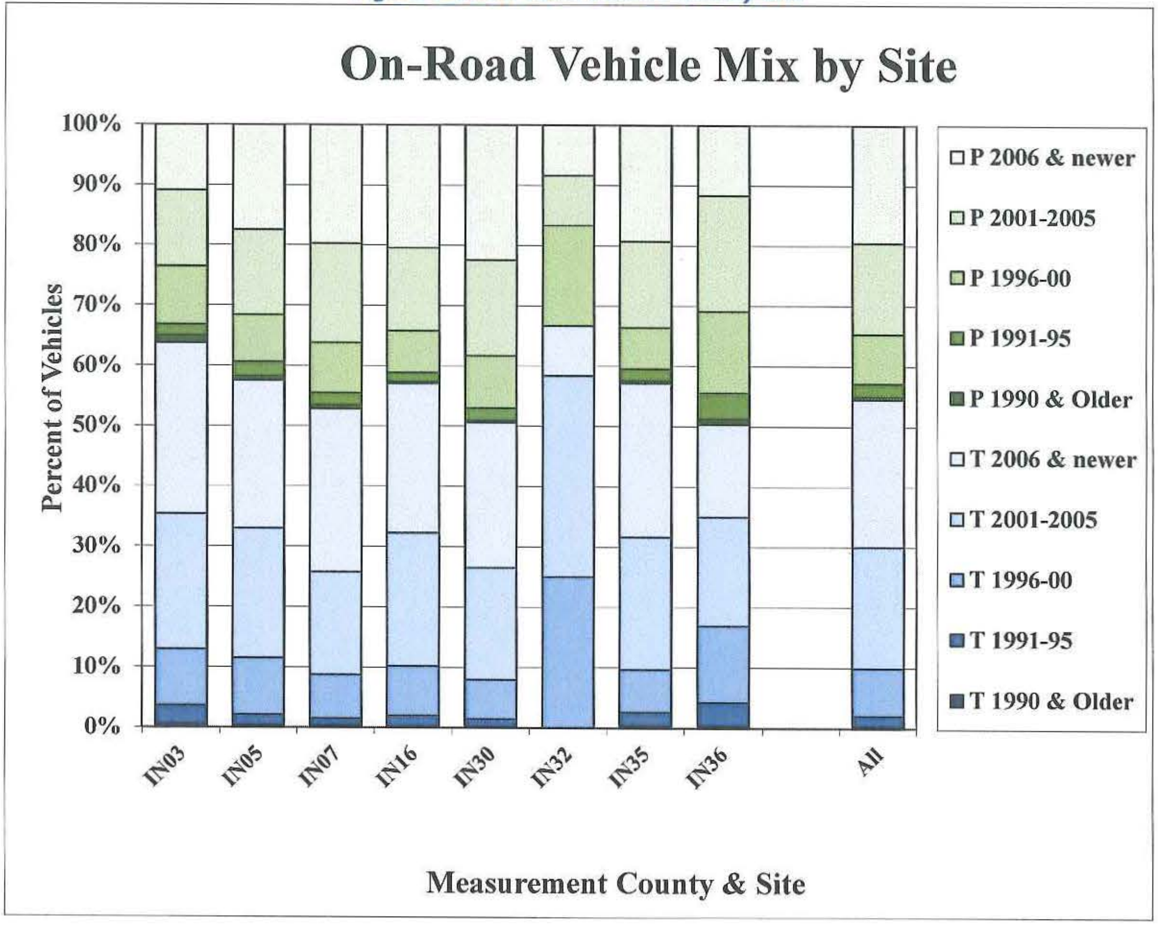
3.1.2 Vehicle Composition

Vehicle type was identified from the VIN for matched plates. For vehicles registered in Lake and Porter counties these were determined to be:

- Passenger vehicles 46%
- Trucks 54%

Vehicles were then divided into five model year ranges to determine if the mix of vehicles by type and model year was consistent among sites. Figure 3-1: On-road Vehicle Mix by Site shows differences in the proportion of passenger vehicles and the age of vehicles.

Figure 3-1: On-road Vehicle Mix by Site



3.2 On-road Fleet Emission Distribution

The following four charts show the emission percentiles for HC, CO, NO_X, and UV Smoke for all Indiana plate vehicles measured in the 5 to 22 kilowatts per metric ton (kW/t) range. Pollutant values are shown on the left y-axis.

Upper black lines indicate the % of the pollutant (right y-axis) produced by a given % of vehicles (x-axis) when rank ordered from highest to lowest. This indicates 20% of vehicles account for 80% of CO, 90% of HC, 90% of NO_X, and 70% of PM (UV Smoke) emissions.

The vast majority of vehicles have low emissions and contribute little to regional pollution. Ten-to-twenty percent of vehicles have much higher emissions and emit over 70-90% of the on-road light-duty vehicle emissions.

Figure 3-2: CO Emissions Distribution

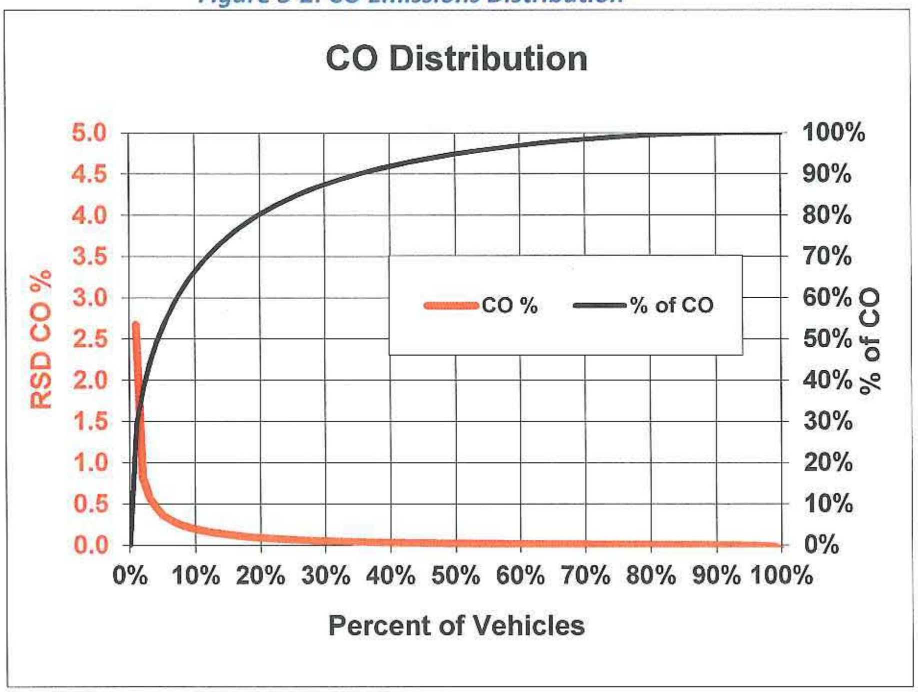


Figure 3-3: HC Emissions Distribution

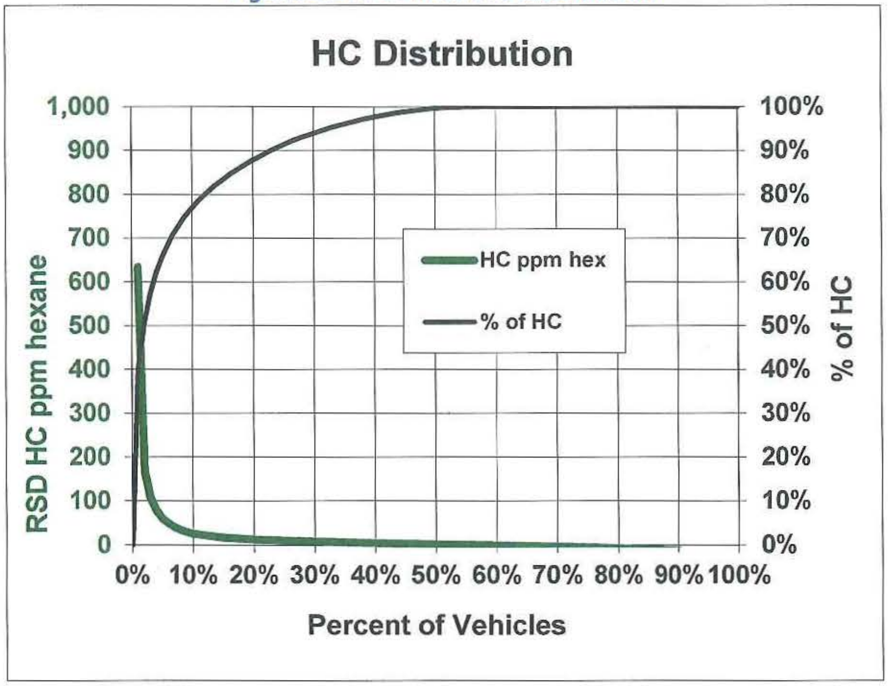


Figure 3-4: NO_X Emissions Distribution

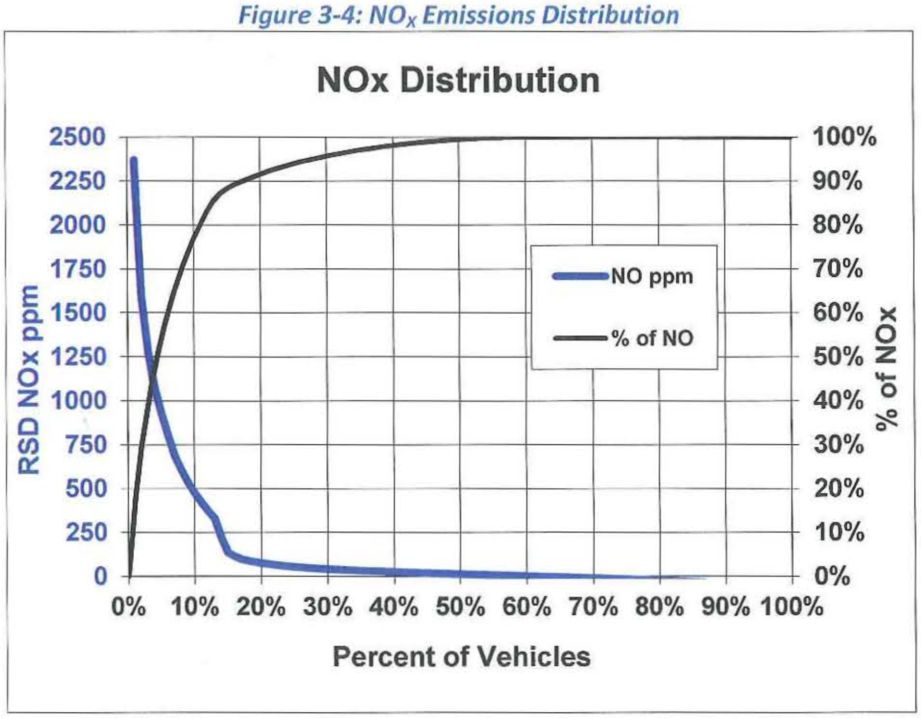
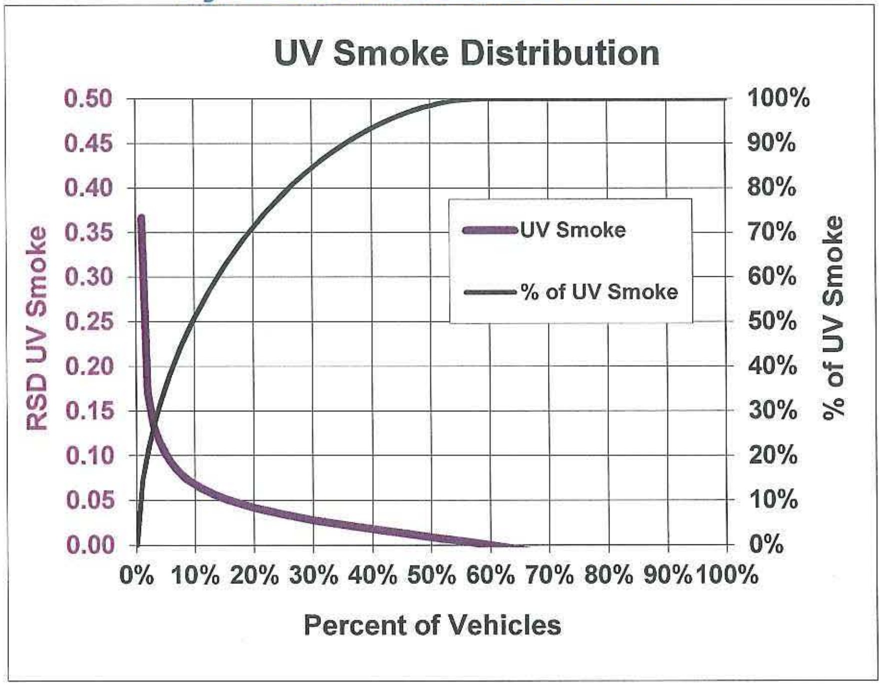


Figure 3-5: UV Smoke Emissions Distribution



3.3 Emissions by Registered Jurisdiction

In this section, emissions of vehicles registered in the different areas are compared (independent of where they were seen driving). Table 3-2 and Figures 3-7 to 3-10 show mean HC, CO, NO_X, and Smoke measurements by jurisdiction. Data about the vehicles such as their type and model was only available for vehicles registered in Lake and Porter counties. Therefore, the results shown are for all vehicles from a jurisdiction and it is not known whether the vehicles from the different jurisdictions have a similar mix of vehicles by age and type. Thus one cannot draw many conclusions from the charts.

To assess whether the comparison of emission values may be affected by different vehicle operating conditions, the average vehicle specific power for each group is plotted in Figure 3-6. Average VSP was similar for all jurisdictions.

Vehicles registered in Indiana counties outside the I/M area had average HC, CO, and NOx emissions of 45%, 47% and 52% higher respectively than the average emissions of vehicles registered in Lake and Porter counties. The difference resulted from a combination of an older age profile and higher emissions for vehicles in the same age range – especially for light trucks.

Compared to Lake and Porter registered vehicles, vehicles from Illinois and Michigan also had higher emissions of HC, CO and NO_X. Vehicles from other more distant states had emissions similar or lower than Lake and Porter registered vehicles.

Figure 3-6: Jurisdiction of Vehicles Measured

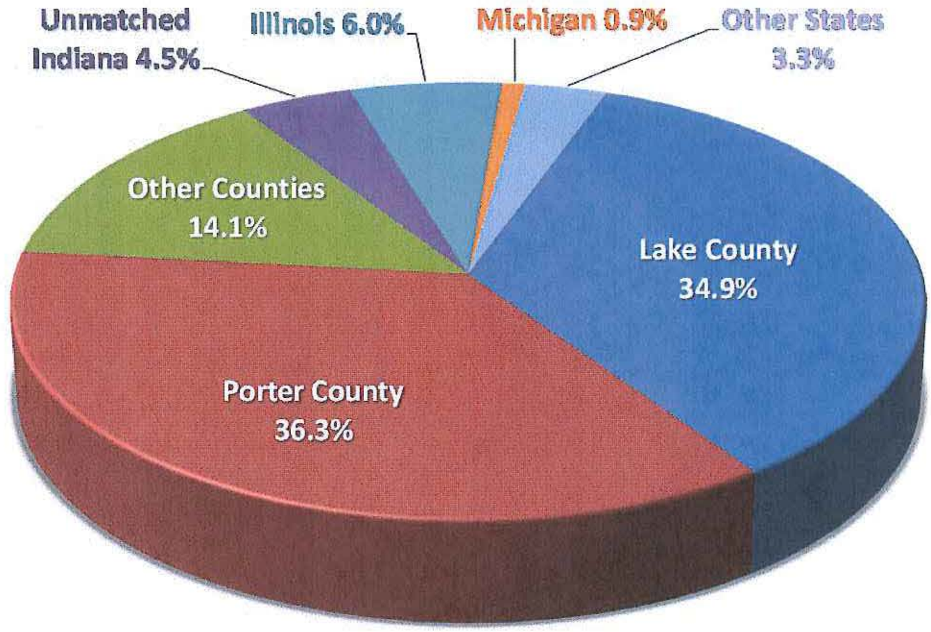


Table 3-2: Emissions by Jurisdiction

Jurisdiction	N	CO	HC	NOx	Smoke	VSP
Lake County	7,254	0.09	15	116	0.013	14.4
Porter County	7,542	0.08	8	110	0.010	14.7
Other Indiana Counties	2,941	0.12	17	171	0.017	14.5
Unmatched Indiana	935	0.08	8	103	0.009	14.4
Illinois	1,253	0.12	20	124	0.014	14.0
Michigan	194	0.11	26	179	0.010	14.9
Other States	679	0.06	9	105	0.006	14.0
Total	20,798	0.09	12	122	0.012	14.5

Figure 3-7: RSD HC Emissions by Jurisdiction

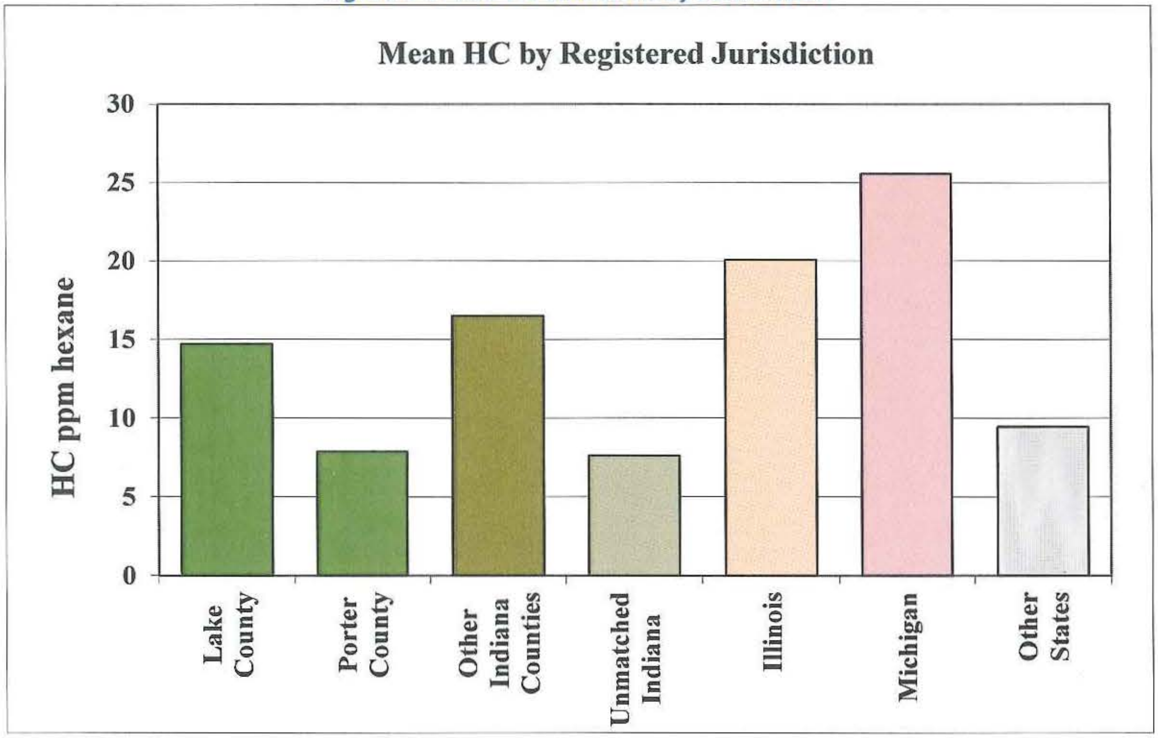


Figure 3-8: RSD CO Emissions by Jurisdiction

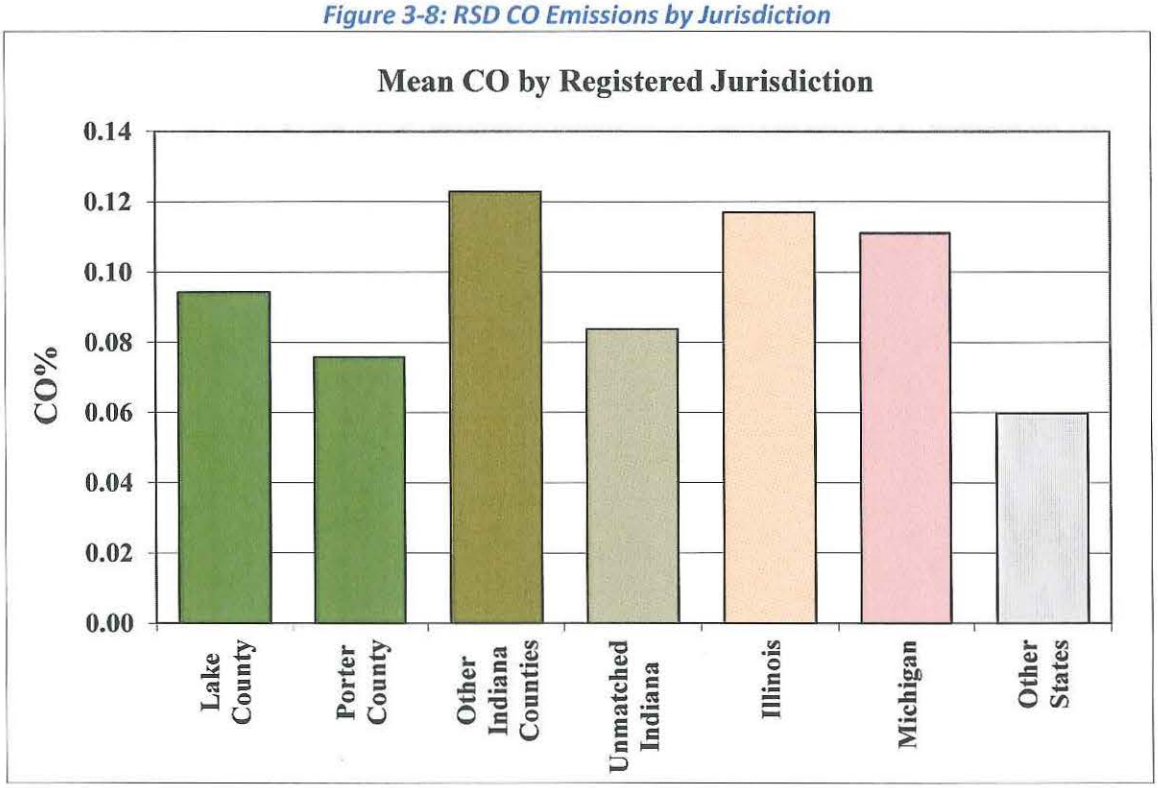


Figure 3-9: RSD NO_X Emissions by Jurisdiction

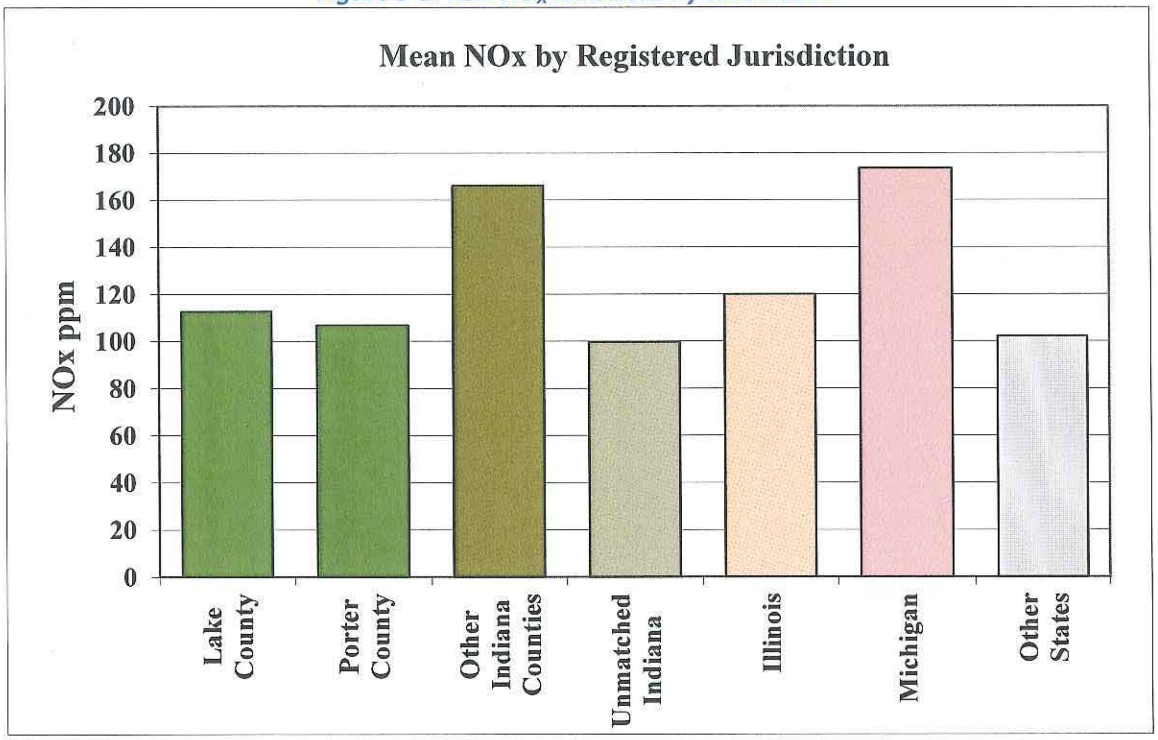


Figure 3-10: RSD UV Smoke Emissions by Jurisdiction

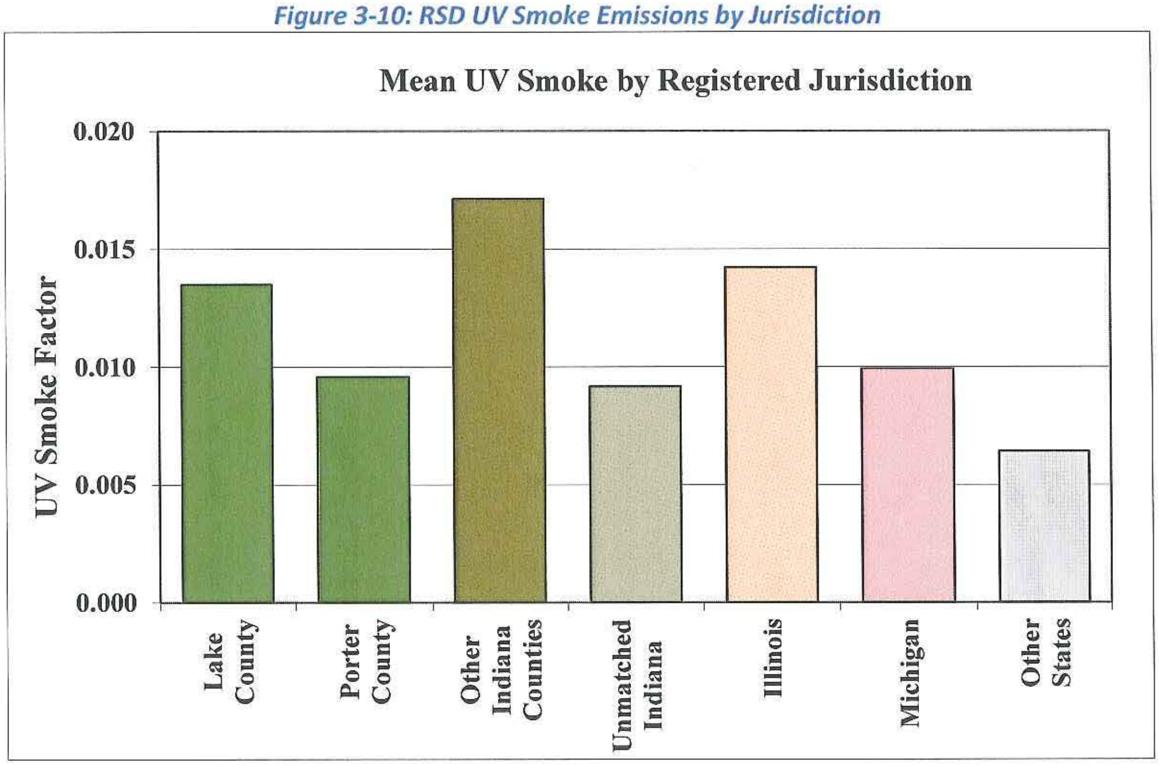
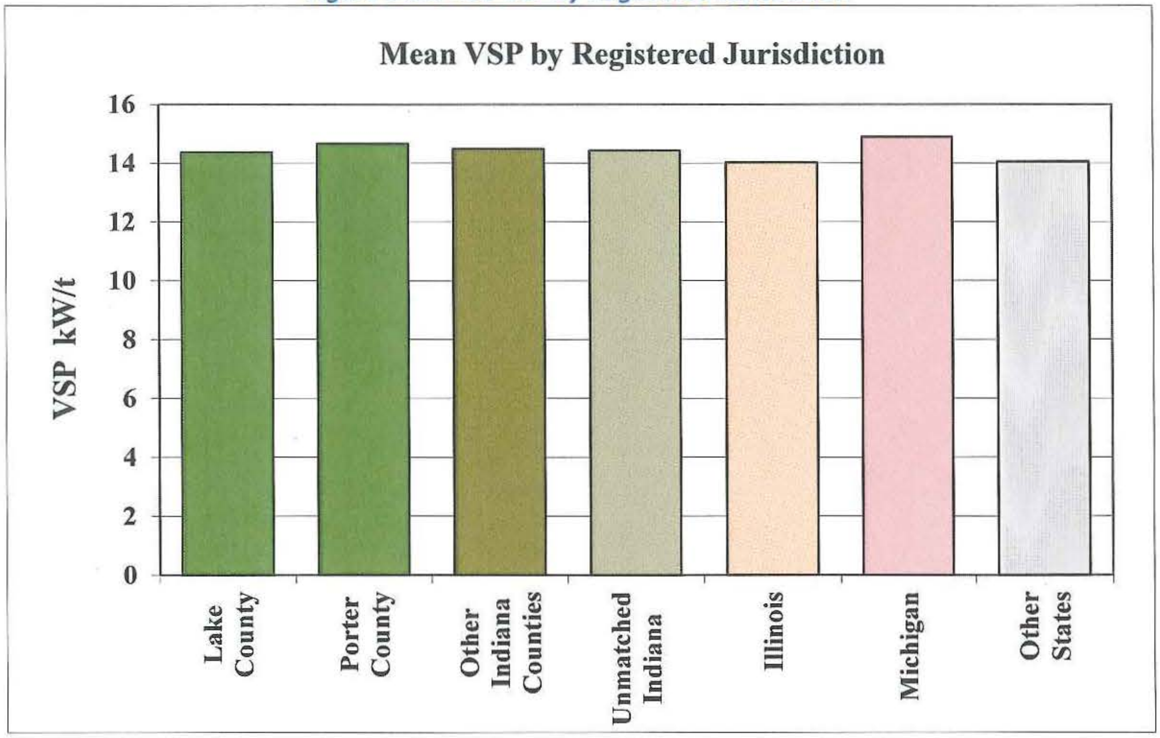


Figure 3-11: RSD VSP by Registered Jurisdiction



3.4 Emissions by Type and Model Year

Emissions for different models by 5-year bins are shown in Figure 3-12 for Lake and Porter counties passenger vehicles and light-duty trucks.

The difference in average emissions between the oldest and newest models is extreme. Only 63 passenger vehicles and 29 trucks model year 1990 and older were measured. Other bins contained at least 200 measurements. 1995 and older models were many times dirtier than newer models. Even 1996-2000 models had emissions several times those of 2006-2010 models. 1991-1995 model trucks had higher emissions than passenger vehicles and 1996-2000 model trucks had higher NO_X and PM.

Figure 3-12: Emissions by Vehicle Type and Model Year

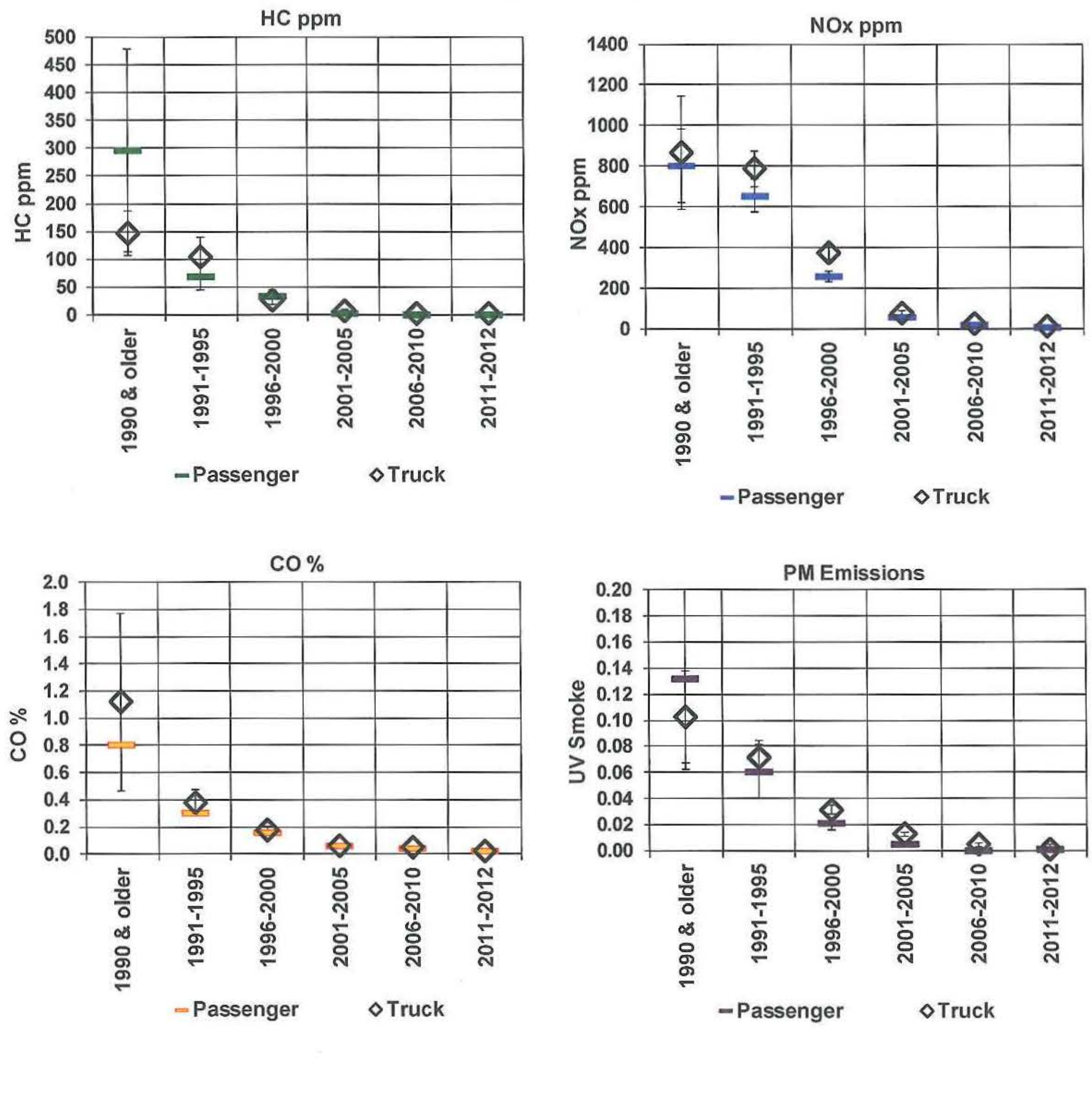


Figure 3-13 compares average emissions of passenger vehicles in Lake and Porter counties. Differences were not statistically significant.

Figure 3-13: Lake and Porter Counties Passenger Vehicle Emissions

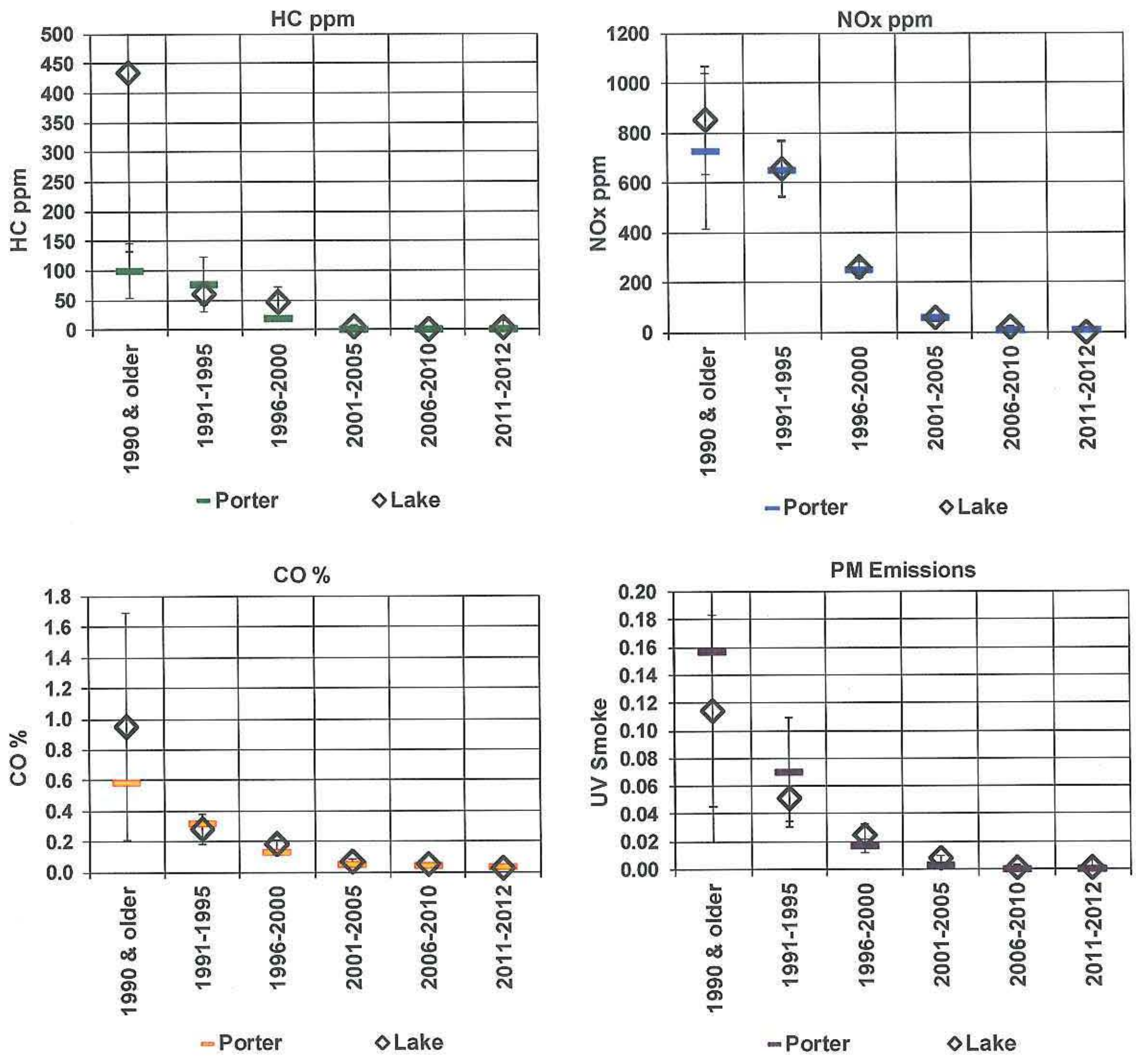
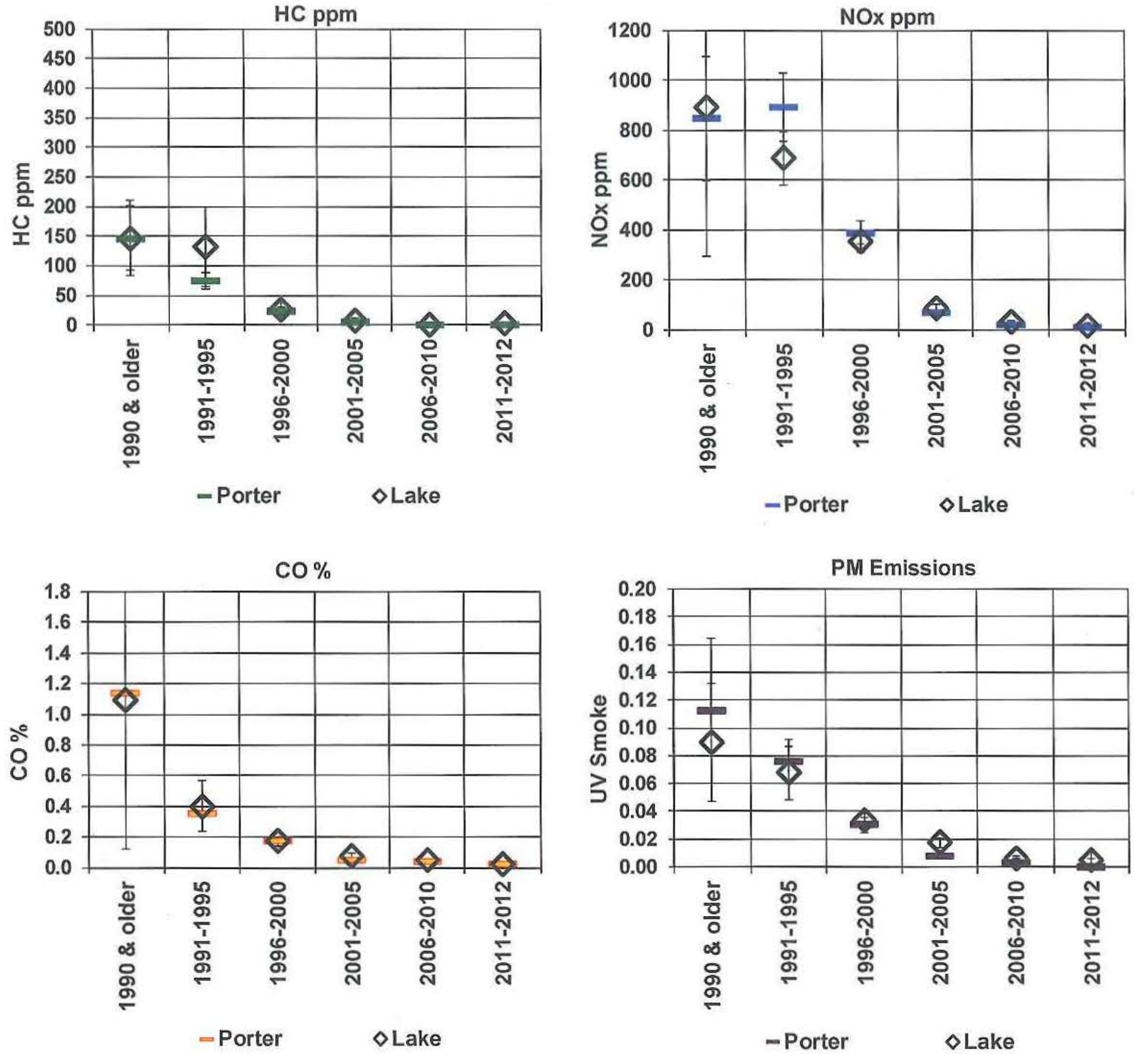


Figure 3-14 compares average emissions of light-duty trucks in Lake and Porter counties. Differences were not statistically significant.

Figure 3-14: Lake and Porter Counties Light-Duty Truck Emissions



The relationship between UV Smoke Factor and mass for gasoline PM estimates is approximate. Gasoline particulates have different characteristics than diesel particulates and, as noted earlier, an accurate characterization of typical gasoline vehicle particulates and their mass correlation to RSD UV Smoke Factor is the subject of continuing research.

Figure 3-15 compares average emissions of Lake and Porter passenger vehicles and passenger vehicles registered in other counties. Differences were not statistically significant. There were 22 passenger vehicles in the Other counties 1990 & older bin and 86 in the 1991-1995 bin. Other bins contained at least 200 measurements.

Other county passenger vehicles in aggregate had 10%, 49%, 35%, and 34% higher average emissions of HC, CO, NO_X, and PM respectively. Using a combined common age profile, other county passenger vehicles had 14% lower HC and 30%, 14%, and 10% higher CO, NO_X, and PM respectively.

Figure 3-15: Lake/Porter and Other Counties Passenger Vehicle Emissions

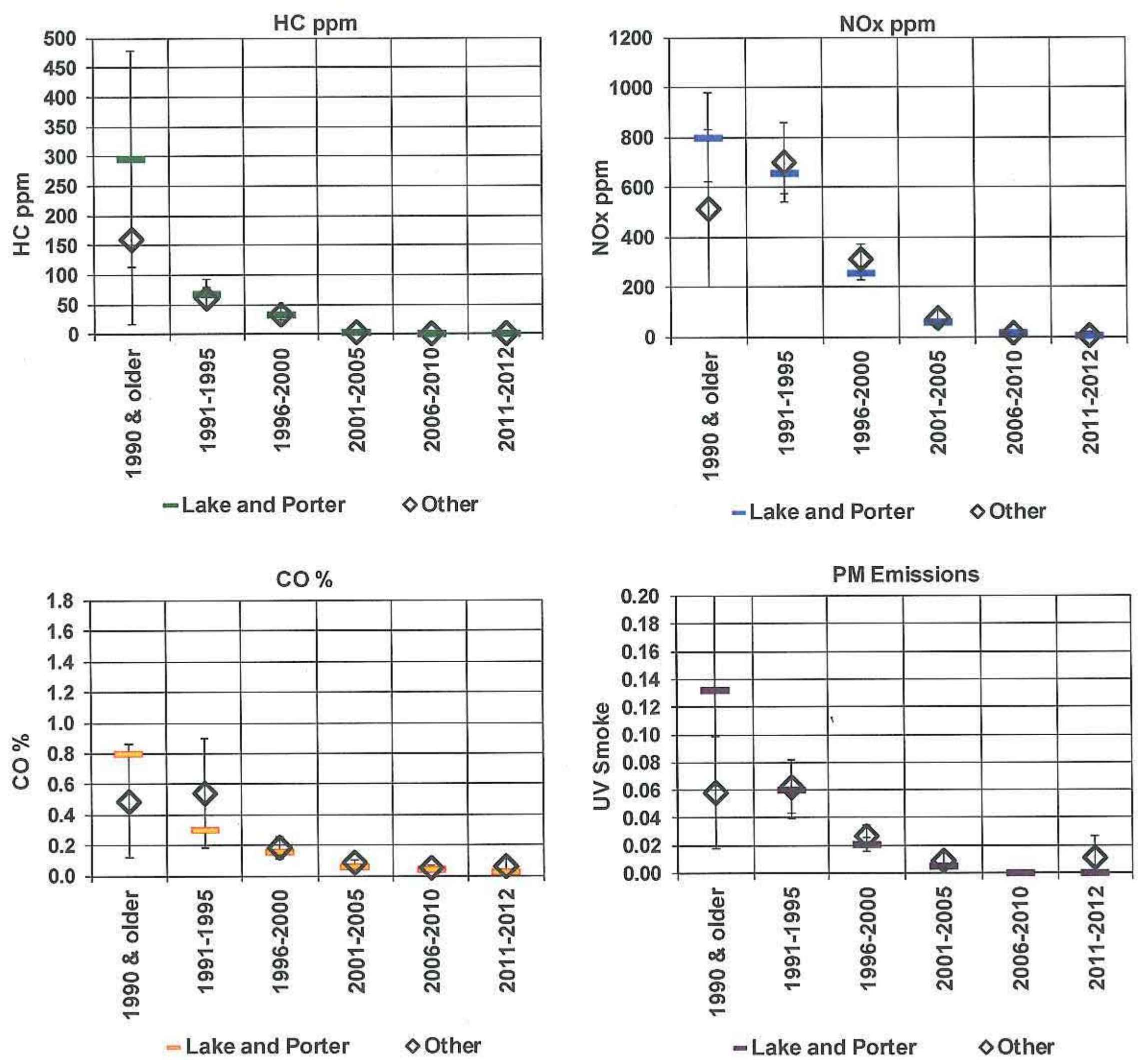
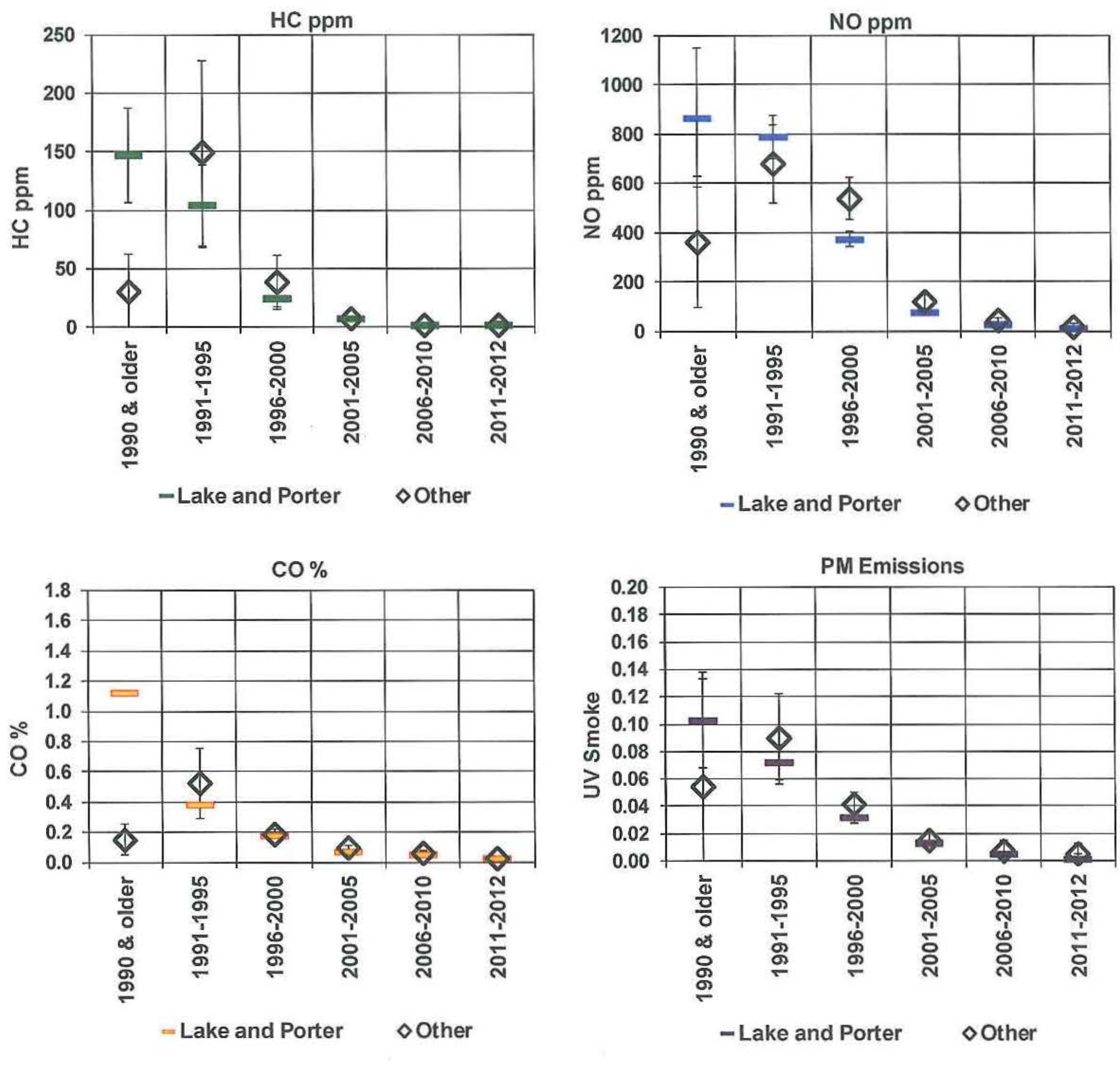


Figure 3-16 compares average emissions of Lake and Porter light-duty trucks and light-duty trucks registered in other counties. There were 17 light-duty trucks vehicles in the Other counties 1990 & older bin and 97 in the 1991-1995 bin. Other bins contained at least 200 measurements.

Other county light-duty trucks in aggregate had 91%, 42%, 67%, and 59% higher average emissions of HC, CO, NO_X, and PM respectively. Using a combined common age profile, other county light-duty trucks had 29%, 17%, 32%, and 28% higher HC, CO, NO_X, and PM respectively.

Figure 3-16: Lake/Porter and Other Counties Light-Duty Truck Emissions



3.5 Emission Contributions by Type and Age

Table 3-3 and Figure 30-17 show the split between Lake and Porter registered passenger vehicles and light-duty trucks in numbers and their estimated emissions contributions. Light-duty trucks were 54.4% of vehicles observed compared to 45.6% passenger vehicles.

Relative emission contributions in Table 3-3 and Figure 3-17 were calculated using a simplified approach: emission contribution is proportional to the number of measurements times the emission levels. The number of RSD measurements of a class of vehicles has been demonstrated in studies[6] to be proportional to the VMT of the class, i.e. the greater the miles driven by a class of vehicle the more often its members are observed on-road. The mass of exhaust per mile is inversely proportional to fuel economy, i.e. better fuel economy equated to a smaller mass of exhaust emissions per mile. Mass emissions are consequently proportional to the average emission concentrations times the number of observations divided by fuel economy. This allows the relative share or contribution of emissions produced by different classes of vehicles to be calculated.

Average fuel economies of 23 mpg for passenger vehicles and 17 mpg for light-duty trucks were used in the calculations. This is reasonable if fuel economy is similar across all age groups (fuel economy has changed little since the early 1980's). More accurate estimates could be obtained by determining and applying the individual fuel economy for each vehicle.

Using the simple approach described above, light-duty trucks are estimated to contribute 60.9%, 56.0%, 63.7%, and 69.7% of the light-duty vehicle sector CO, HC, NO_X, and PM (UV Smoke) emissions. It is assumed that UV Smoke is a reasonable measure of total particulate emissions.

Table 3-3: Vehicles and Emission Contributions by Type and Age

		Emission Contributions			
Type	Vehicles	CO	HC	NOx	PM
Passenger	45.6%	39.1%	44.0%	36.3%	30.3%
Truck	54.4%	60.9%	56.0%	63.7%	69.7%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Within passenger vehicles, Table 3-4 shows that 1995 and older models were 5.2% of measurements contributing 44.9% of HC and 33.2% of NO_X. In contrast, 2006-2012 models were 43.5% of measurements contributing un-measurable HC and 5.8% of NO_X.

The lower section of Table 3-4 shows the light-duty trucks measured were predominantly 2001 and newer models (83%) contributing 32.1% of light-duty truck HC and 34.3% of light-duty truck NO_X.

Figures 3-18 and 3-19 further illustrate the split of vehicles and contributions within the passenger vehicle and light-duty truck sectors.

Figure 3-17: Passenger and Light-Duty Truck Emission Contributions

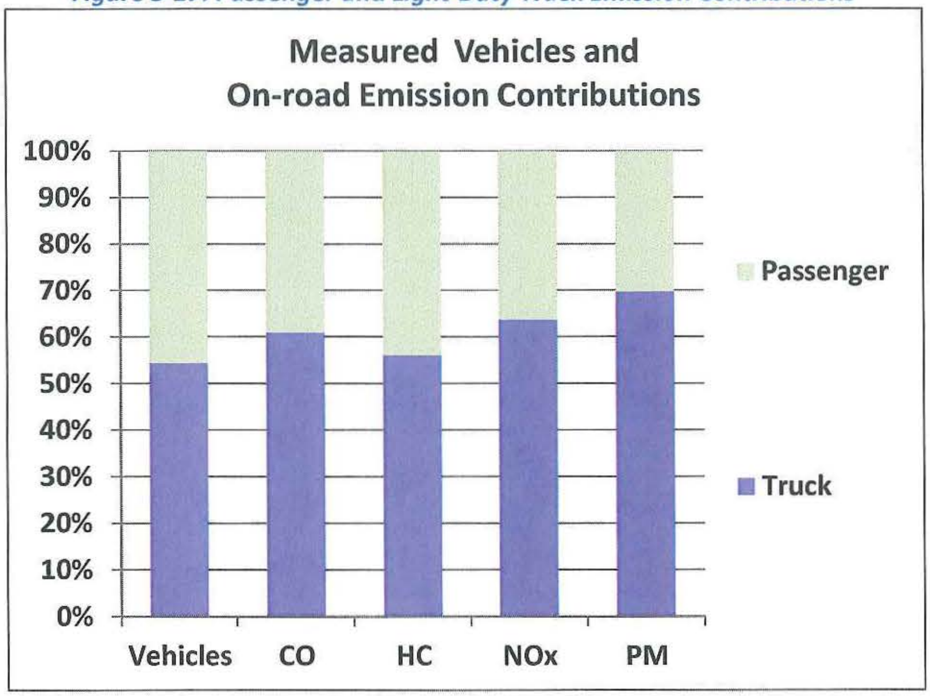


Table 3-4: Vehicles and Emission Contributions by Age

		Passenger Vehicle Emission Contributions			
Model Years	**Vehicles**	**CO**	**HC**	**NOx**	**PM**
1990 & older	0.9%	8.7%	21.9%	7.0%	13.3%
1991-1995	4.3%	14.8%	23.0%	26.2%	27.9%
1996-2000	17.8%	32.1%	46.1%	42.8%	39.7%
2001-2005	33.4%	23.7%	9.1%	18.2%	19.0%
2006-2010	39.1%	19.4%	0.0%	5.6%	0.0%
2011-2012	4.4%	1.3%	0.0%	0.2%	0.1%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

		Light Truck Emission Contributions			
Model Years	**Vehicles**	**CO**	**HC**	**NOx**	**PM**
1990 & older	0.4%	4.9%	5.3%	2.7%	2.8%
1991-1995	2.6%	12.1%	27.4%	17.8%	14.3%
1996-2000	14.1%	29.7%	35.1%	45.1%	33.5%
2001-2005	37.3%	28.9%	25.5%	24.8%	34.9%
2006-2010	40.7%	22.9%	6.0%	9.0%	14.1%
2011-2012	5.0%	1.6%	0.6%	0.5%	0.5%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Figure 3-18: Passenger Vehicle Emission Contributions by Age

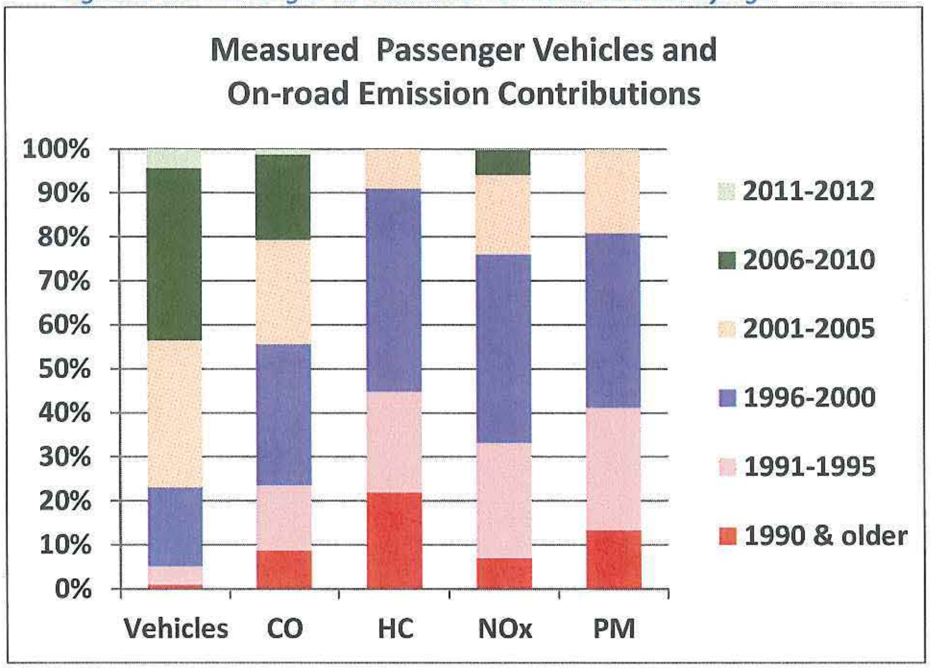
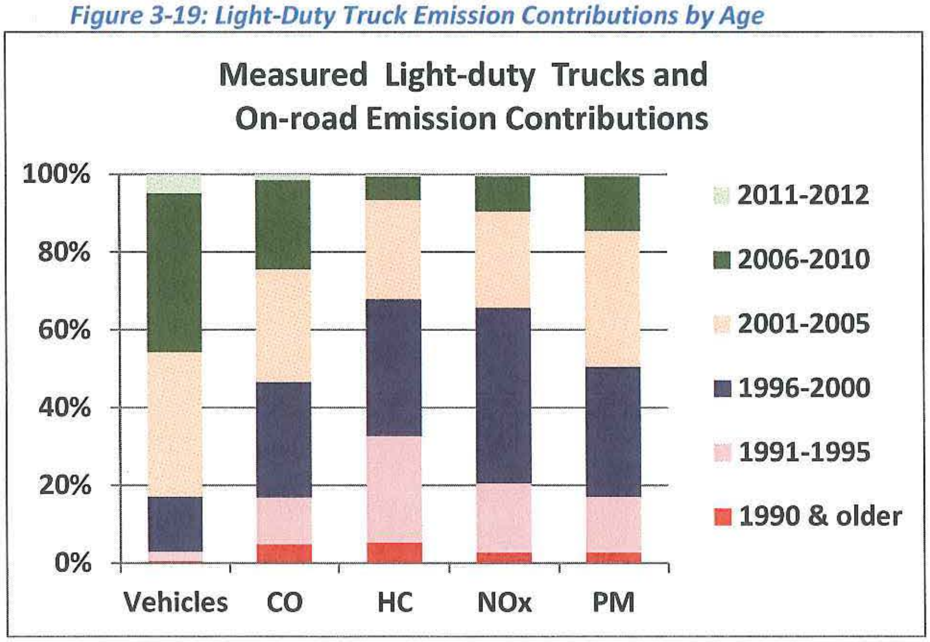


Figure 3-19: Light-Duty Truck Emission Contributions by Age



4 I/M STATUS OF ON-ROAD VEHICLES

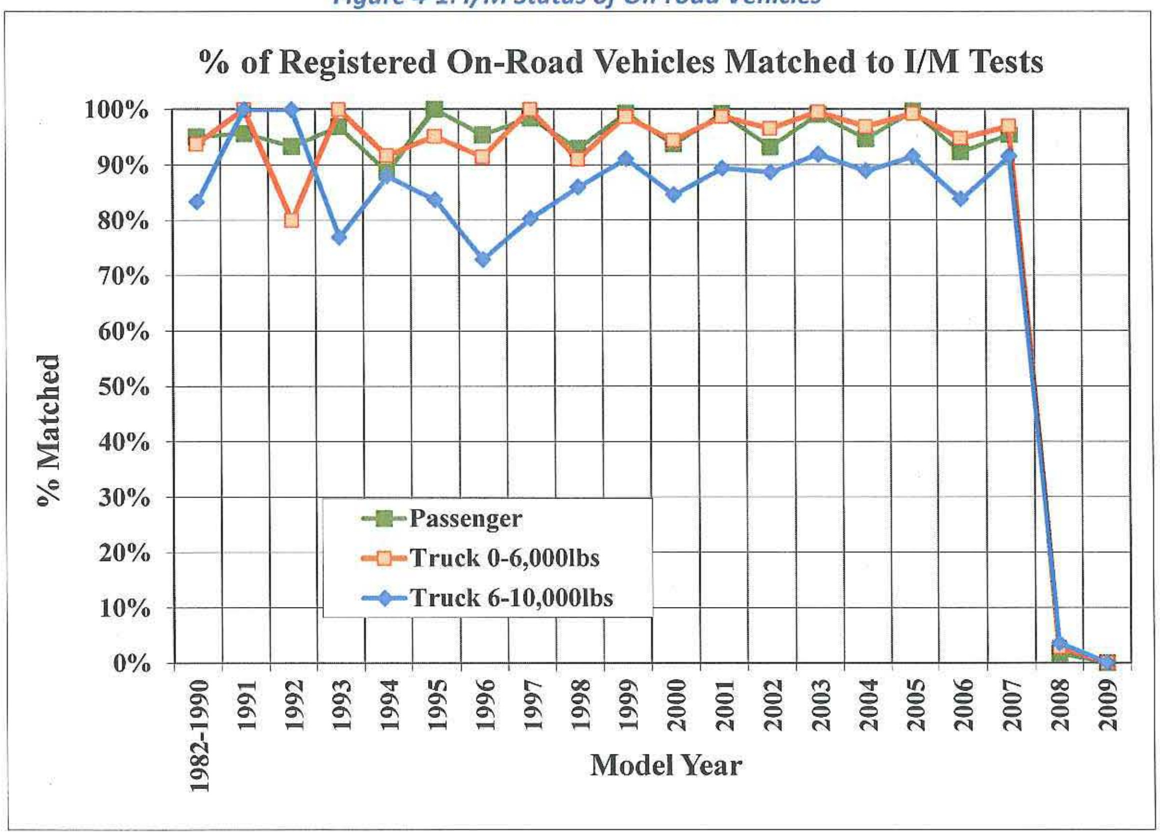
Envirotest compared on-road emissions to the previous I/M inspection result for gasoline and diesel powered vehicles registered within the two counties. I/M records from 2009-2011 were analyzed to extract the date and the result of the last I/M test.

Figure 4-1: I/M Status of On-road Vehicles summarizes the status of vehicles observed on-road by model year. Vehicles as old as 1976 models were subject to inspection but the oldest model vehicles identified as being registered to Lake or Porter counties were 1982 models.

Because of the four-year new model exemption, 2008 and newer models were not required to have obtained an emissions inspection at the time the data were reviewed.

The upper orange and green lines show that 95.9% of 1982-2007 passenger models and 96.8% of trucks 6,000lbs GVWR or less had obtained at least one inspection between 1/1/2009 and 12/31/2011. The equivalent rate for trucks between 6,000 and 10,000lbs GVWR and greater was 88.3%. Some of these are exempt from testing as the upper weight limit on the inspection requirement is 9,000lbs GVWR. Diesel fueled vehicles were excluded.

Figure 4-1: I/M Status of On-road Vehicles



There is an obvious biennial pattern in the results showing the rate of matched tests was higher for odd model year vehicles. Odd model-year vehicles were covered by two of the years of test data reviewed for matched inspections (2009 & 2011), which may account for the higher percentage. A similar pattern was observed in the 2009 survey.

Figure 4-2: I/M Status of On-road Vehicles by County shows on-road vehicles with test matched records by county for the 1976-2007 models by fuel, type (P-passenger, T-truck) and truck weight class (1 or 2). Figure 4-3 confirms that inspection rates were similar in the two counties.

Figure 4-2: I/M Status of On-road Vehicles by County

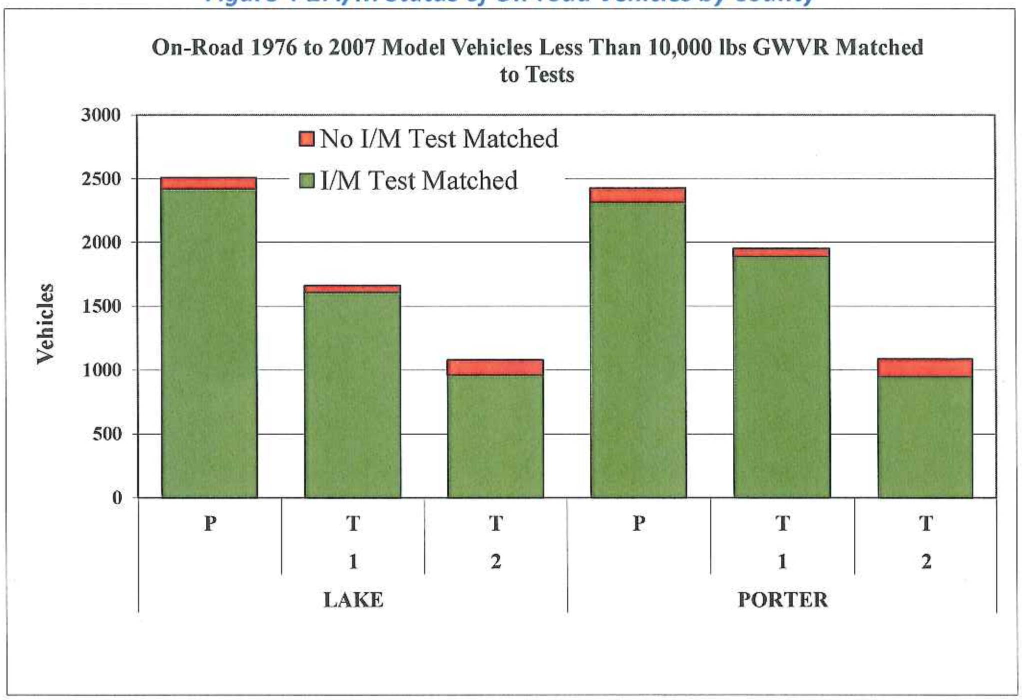
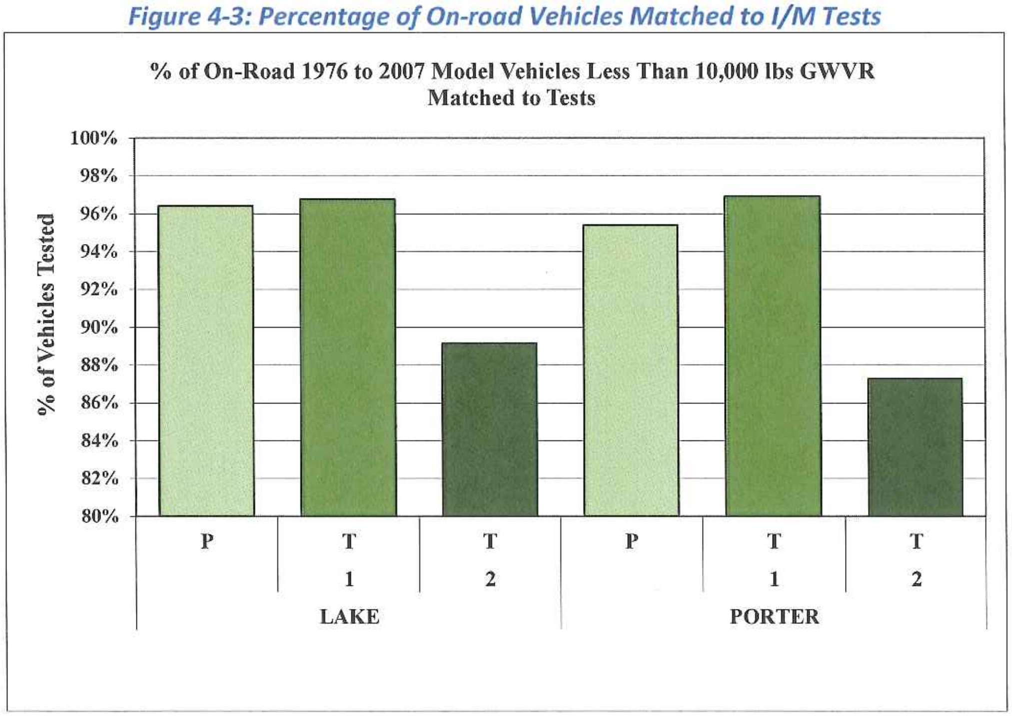


Figure 4-3: Percentage of On-road Vehicles Matched to I/M Tests



5 High Emitters

For this survey, high emitters were identified using cutpoints listed in Table 5-1, which have been used to identify high emitters in Maryland surveys. Vehicles were divided into three GVWR classes: 1) 0 to 6,000 lbs, 2) 6,001 to 10,000 lbs, and 3) over 10,000 lbs. The cutpoints for HC in this table are specified in ppm HC hexane, which is consistent with most I/M inspection equipment used to measure tailpipe concentrations. Remote sensing NO_X emissions were corrected for humidity as described in Section 2 before being compared to the high emitter standards.

Table 5-1: On-road High Emitter Cutpoints

	GVWR <= 6,000 lbs			GVWR 6,001-10,000 lbs			GVWR 10,001+ lbs		
	HC	CO	NOx	HC	CO	NOx	HC	CO	NOx
Year	(ppm)	(%)	(ppm)	(ppm)	(%)	(ppm)	(ppm)	(%)	(ppm)
1977	700	7	2,718	700	7	2,557	700	7	5,000
1978	645	7	2,718	700	7	2,557	700	7	5,000
1979	600	6	2,718	700	7	2,045	700	7	5,000
1980	330	2.6	2,718	525	7	2,045	700	7	5,000
1981	330	1.8	2,718	375	4.5	2,045	700	7	5,000
1982	330	1.8	2,718	330	3.8	2,045	700	7	5,000
1983	330	1.8	2,718	330	2.3	2,045	700	5.3	5,000
1984	264	1.8	2,252	311	1.8	1,969	660	4.5	4,500
1985	264	1.8	2,252	292	1.8	1,969	660	4.5	4,500
1986	264	1.8	2,252	292	1.8	1,969	420	3.8	4,500
1987	264	1.8	2,252	187	1.8	1,969	330	1.8	4,500
1988	264	1.8	1,243	180	1.8	1,917	330	1.8	4,500
1989	264	1.8	1,243	180	1.8	1,917	330	1.8	4,500
1990	264	1.8	1,243	180	1.8	1,917	330	1.8	4,500
1991	208	1.8	1,087	168	1.8	1,457	330	1.8	4,000
1992	208	1.8	1,087	168	1.8	1,457	330	1.8	4,000
1993	208	1.8	1,087	168	1.8	1,457	330	1.8	4,000
1994	208	1.8	1,087	168	1.8	1,457	330	1.8	4,000
1995	208	1.8	1,087	168	1.8	1,457	330	1.8	4,000
1996+	100	1.0	893	168	1.0	1,457	330	1.8	3,600

In order to be considered a high emitter in Maryland, a vehicle was required to have 2 or more readings that exceed the standards for the same pollutant on different days. If the standard is exceeded by less than the tolerance of the RSD unit, a third measurement is required for confirmation.

Some 1,856 vehicles had two or more valid remote sensing measurements on different days within the normal VSP operating range of 3 to 22 kW/t. Thirty-two (1.7%) of these exceeded the cutpoints on both of their last two measurements for the same pollutant having average emissions of 329 ppm HC, 0.6% CO, and 1,503 ppm NO_X.

Fifteen percent of high emitters were 1995 and older models and 25% were 1996-1999 models.

Vehicles with out-of-state registrations were not considered in the high emitter analysis because their type and model year was unknown. Correct high emitter cutpoints cannot be selected without this information.

As summarized in Table 5-2, under the Maryland rules, 13 of the 32 suspected high emitters required additional confirmation by a third measurement. Those not requiring a third measurement are listed in Table 5-3. Those requiring a third measurement are listed in Table 5-4.

Table 5-2: High Emitter Summary

Pollutant Exceeded	High Emitter	Suspected	Total
HC only	0	2	2
CO only	2	0	2
NO only	14	11	25
HC & CO	1	0	1
HC & NOx	2	0	2
CO & NOx	0	0	0
All	0	0	0
Total	19	13	32

Third measurements were available on 6 of the 13 suspected high emitters and these are listed in Table 5-5. Five out of the six were confirmed. The vehicle not confirmed had two high NO_X measurements and the third measurement was 78% of the RSD NO_X high-emitter standard.

Six (19%) of the high emitters were registered in counties outside the I/M area.

Table 5-3: High Emitters

Year	Type	Make	Model	GVW Code	Fuel	Registration County	Date Last	Date Prev	HC Values Std	HC Values Last	HC Values Prev	CO Values Std	CO Values Last	CO Values Prev	NOx Values Std	NOx Values Last	NOx Values Prev
High Emitters (Last two measurements both exceed the emissions standards for at least one pollutant by more than the RSD tolerance).																	
1989	P	CHEVROLET	CAPRICE CLASSIC BROUGHAM		G	LAKE	06-Sep-11	01-Sep-11	264	2,386	3,921	1.8	1.3	4.8	1,243	1,613	2,973
1993	P	MAZDA	929		G	PORTER	21-Oct-11	14-Oct-11	208	117	95	1.8	0.3	0.3	1,087	1,900	1,625
1993	T	GMC	SIERRA K1500	2	G	PORTER	19-Aug-11	17-Aug-11	168	159	157	1.8	0.8	0.6	1,457	2,916	3,174
1995	P	HONDA	CIVIC EX		G	LAKE	17-Jun-11	01-Jun-11	208	5	8	1.8	0.0	0.0	1,087	2,553	2,263
1995	P	HONDA	CIVIC LX		G	LAKE	08-Jul-11	30-Jun-11	208	195	208	1.8	0.6	0.8	1,087	2,331	2,463
1995	T	DODGE	DAKOTA	1	G	LAKE	08-Jun-11	01-Jun-11	208	39	207	1.8	0.1	0.5	1,087	1,396	1,368
1996	P	CADILLAC	DEVILLE		G	LAKE	06-Jul-11	30-Jun-11	100	(18)	182	1.0	0.0	0.1	893	1,607	1,305
1996	P	MERCURY	SABLE LS		G	LAKE	06-Sep-11	01-Sep-11	100	4,333	4,596	1.0	3.5	1.7	893	769	1,517
1996	T	CHEVROLET	BLAZER	1	G	LAKE	17-Jun-11	08-Jun-11	100	71	14	1.0	0.5	0.5	893	1,553	1,206
1996	T	CHEVROLET	BLAZER	1	G	PORTER	14-Oct-11	17-Aug-11	100	77	126	1.0	0.3	0.8	893	1,485	2,278
1996	T	DODGE	DAKOTA	1	G	LAPORTE	02-Nov-11	21-Oct-11	100	44	49	1.0	0.1	0.1	893	2,382	2,204
1996	T	DODGE	RAM 1500	2	G	LAKE	06-Sep-11	08-Jul-11	168	163	226	1.0	1.4	2.1	1,457	1,303	1,336
1998	P	SATURN	SL2		G	LAKE	07-Oct-11	18-Aug-11	100	577	38	1.0	0.8	0.1	893	1,474	1,997
1999	T	JEEP	GRAND CHEROKEE LAREDO	1	G	LAKE	17-Jun-11	08-Jun-11	100	99	52	1.0	0.5	0.5	893	2,516	1,631
1999	T	DODG	RAM WAGON B3500	2	G	0	06-Jul-11	30-Jun-11	168	119	79	1.0	0.7	0.4	1,457	2,949	2,348
2000	P	DODGE	AVENGER ES		G	LAPORTE	12-Oct-11	07-Oct-11	100	71	136	1.0	0.2	0.3	893	2,573	2,050
2000	T	CHEVROLET	BLAZER	1	G	LAKE	06-Jul-11	30-Jun-11	100	114	148	1.0	0.7	0.9	893	1,374	1,802
2000	T	CHEVROLET	EXPRESS G2500	2	G	LAKE	17-Jun-11	08-Jun-11	168	45	11	1.0	2.7	2.1	1,457	(13)	(12)
2002	P	CHRYSLER	CONCORDE LIMITED		G	LAKE	17-Jun-11	01-Jun-11	100	79	125	1.0	0.5	0.5	893	1,662	1,205

Table 5-4: High Emitters Requiring a Third Measurement

						Registration	Date		HC Values			CO Values			NOx Values		
Year		Make	Body Style			County	Last	Prev	Std	Last	Prev	Std	Last	Prev	Std	Last	Prev
A third reading is needed to verify high emitter status (The last two measurements exceed standard by less than the RSD tolerance).																	
1992	P	CHEVROLET	CAVALIER VL/RS		G	PORTER	02-Nov-11	14-Oct-11	208	19	4	1.8	0.2	0.2	1,087	1,293	1,090
1993	T	DODGE	DAKOTA	1	G	PORTER	02-Nov-11	19-Aug-11	208	185	91	1.8	0.6	0.4	1,087	1,244	1,163
1993	T	PLYMOUTH	VOYAGER SE	1	G	PORTER	06-Jul-11	30-Jun-11	208	238	95	1.8	0.2	0.1	1,087	1,315	1,681
1996	P	FORD	ESCORT LX		G	PORTER	17-Jun-11	01-Jun-11	100	49	11	1.0	0.0	0.0	893	1,043	1,064
1997	P	DODGE	NEON HIGHLINE/SPORT		G	NEWTON	18-Aug-11	27-Jul-11	100	116	109	1.0	0.4	0.3	893	21	360
1997	P	SATURN	SL1		G	LAKE	17-Jun-11	08-Jun-11	100	(18)	(3)	1.0	0.0	0.0	893	1,333	945
1998	P	DODGE	NEON/HIGHLINE/SPORT/LE		G	LAPORTE	18-Aug-11	11-Aug-11	100	97	202	1.0	0.4	0.3	893	1,749	934
1998	P	VOLKSWAGEN	PASSAT GLS		G	TIPPECANOE	27-Jul-11	22-Jul-11	100	236	436	1.0	0.0	0.1	893	635	679
1998	T	GMC	JIMMY	1	G	LAKE	17-Jun-11	01-Jun-11	100	131	(15)	1.0	0.4	0.2	893	1,222	922
2000	P	CHEVROLET	MONTE CARLO SS		G	JASPER	17-Aug-11	27-Jul-11	100	(28)	(9)	1.0	0.1	0.5	893	985	1,088
2000	T	CHEVROLET	S10	1	G	PORTER	21-Oct-11	14-Oct-11	100	12	(15)	1.0	0.3	0.2	893	1,108	1,180
2002	P	VOLKSWAGEN	JETTA GLS TDI		D	PORTER	17-Jun-11	08-Jun-11	100	3	(10)	1.0	0.0	0.0	893	1,144	1,012
2002	T	JEEP	GRAND CHEROKEE LAREDO	1	G	LAKE	17-Jun-11	08-Jun-11	100	20	33	1.0	0.2	0.2	893	909	976

Table 5-5: Suspected High Emitters With a Third Measurement

				Date			HC Values				CO Values				NOx Values			
Year	Make	Body Style	Registration County	Last	Prev	2nd Prev	Std	Last	Prev	2nd Prev	Std	Last	Prev	2nd Prev	Std	Last	Prev	2nd Prev
1992	CHEVROLET	CAVALIER VL/RS	PORTER	02-Nov-11	14-Oct-11	27-Jul-11	208	19	4	-14	1.80	0.2	0.2	0.1	1087	1,293	1,090	849
1993	MAZDA	929	PORTER	21-Oct-11	14-Oct-11	10-Aug-11	208	117	95	148	1.80	0.3	0.3	0.4	1087	1,900	1,625	1,232
1996	DODGE	DAKOTA	LAPORTE	02-Nov-11	21-Oct-11	14-Oct-11	100	44	49	23	1.00	0.1	0.1	0.1	893	2,382	2,204	2,587
1996	MERCURY	SABLE LS	LAKE	06-Sep-11	01-Sep-11	31-Aug-11	100	4333	4596	4457	1.00	3.5	1.7	1.8	893	769	1,517	1,259
1996	CHEVROLET	BLAZER	LAKE	17-Jun-11	08-Jun-11	01-Jun-11	100	71	14	53	1.00	0.5	0.5	0.6	893	1,553	1,206	1,292
1999	JEEP	GRAND CHEROKEE	LAKE	17-Jun-11	08-Jun-11	01-Jun-11	100	99	52	49	1.00	0.5	0.5	0.4	893	2,516	1,631	1,405

6 Clean Vehicles

The emissions distributions in Section 3 showed that the vast majority of vehicles are clean. For vehicles measured in 2009, Figures 6-1 and 6-2 show decile emissions of HC and NO_X within model year. In the charts, the 1995 and older models were compressed into two groups because few vehicles were measured for each individual model year of these older models. The charts further illustrate that most of the newer model vehicles have very low emissions. Since, 1996 and newer OBD-II equipped vehicles inform their owners if faults are detected in emission control system components, owners of these models are generally aware of whether their vehicle needs service. Exceptions are faults such as fuel leaks that are not detected by OBD-II but register as high RSD HC emissions on-road.

The on-road measurements, in addition to identifying high-emitters, provides a way of reducing the I/M burden for owners that keep their vehicles well maintained and are responsive to the OBD-II check engine warnings. A Clean Screen program uses RSD measurements to exempt these vehicle owners from a station inspection and allows the funds that would otherwise be spent on station visits to be directed toward the on-road measurements, thereby allowing comprehensive on-road monitoring, and toward support of other emission reduction activities such as repair and scrap programs. The wealth of on-road measurements can be used to focus on the residual high exhaust, high evaporative emitters and smoking vehicles through notifications and repair/scrap assistance programs. The net result is more convenience for owners of clean vehicles and a stronger focus on the small percentage of high emitting or smoking vehicles.

In 2011, surveyed recipients of a clean screen exemption notice together with an information sheet highlighting the importance of responding to the check engine light reported being less likely to ignore the check engine light (60%) and more likely to take the vehicle for service immediately (52%) or at the first opportunity (41%)[7]. A clean screen program provides an opportunity to educate vehicle owners when their attention is focused.

Envirotest has demonstrated modeling of a clean screen program using MOVES[8]. A combination of clean screening and high emitter identification programs linked to incentivized scrap and programs can provide net positive emissions benefits.

Colorado has been running a successful clean screen program in the Denver Metro Area (DMA) since 2003. Current Clean Screen criteria require vehicles to have two RSD measurements with emissions below 200 ppm HC, 0.5% CO, and 1000 ppm NO_X. Vehicles may also pass with a single measurement if the historical fail rate for the model is low.

Ohio will be starting low level clean screening later in 2012. The program will use RSD cutpoints based on ASM standards and a cap on the historical fail rate of vehicles in the same family.

In April 2012, Virginia passed legislation to phase in clean screening starting with 10% of testable vehicles in 2012/2013, 20% in 2013/2014, and up to 30% after July 2014[9]. Virginia intends to scale up its existing RSD high emitter program using the on-road data collected for clean screening.

Figure 6-1: Decile HC Emissions

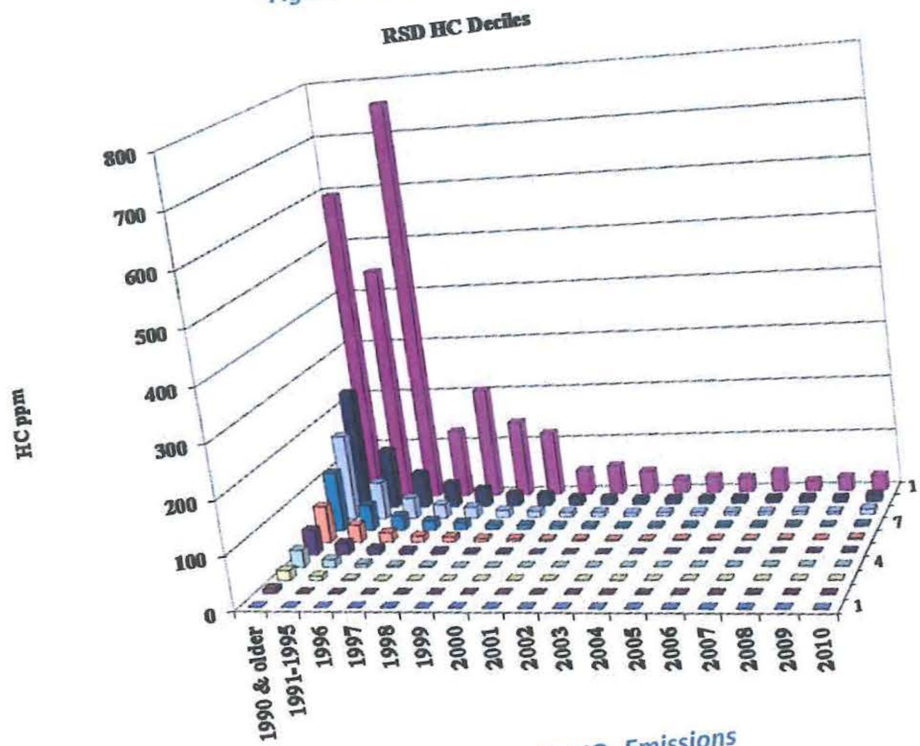
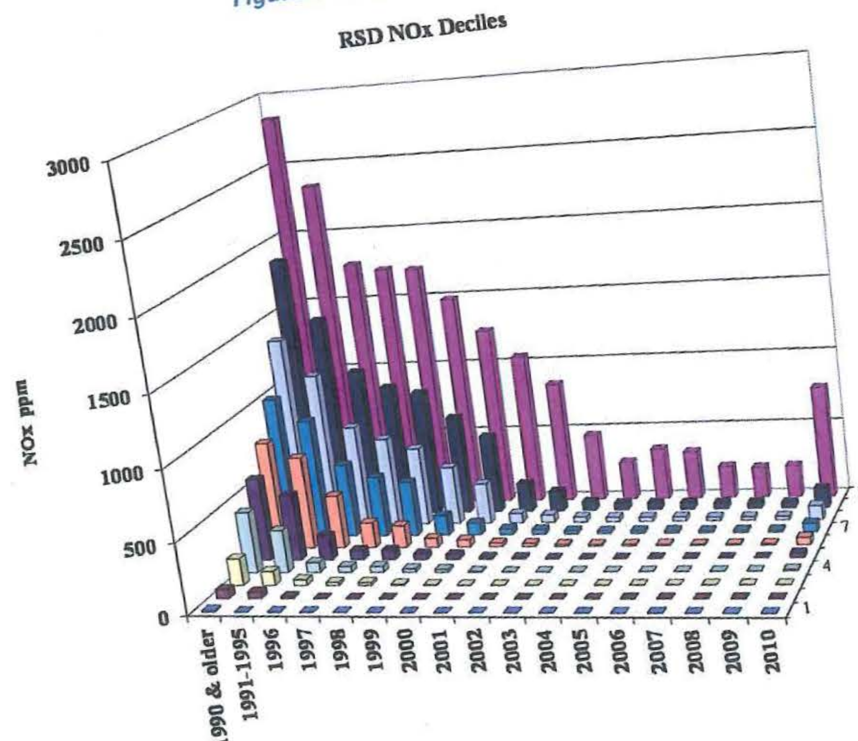


Figure 6-2: Decile NO_X Emissions



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